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An inquiry into the activity and traditional methods of teaching science and their effects upon sixth grade students' content learning, critical thinking ability, and attitude toward science

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Abstract

The identification of factors which increase science achievement and interest among students is a topic of renewed consideration among researchers. Today educators and societal leaders are deeply concerned that the schools are not producing future scientists, engineers, and a citizenry at large who will be able to deal capably and creatively with a high-technology, post-industrial era in American society. Concomitant with this new technological age are the increasingly critical dilemmas of energy production and use, environmental degradation, world food shortage, and the threat of nuclear annihilation. These problems seem to make the need for a scientifically literate public as well as capable, professional scientists even more obvious. News media commentators speak frequently about the grim outlook for the future because of the present shortage of science teachers whom, they say, are already encouraging fewer students every year to look toward careers in science.

AN INQUIRY INTO THE ACTIVITY AND TRADITIONAL METHODS OF TEACHING SCIENCE AND THEIR EFFECTS UPON SIXTH GRADE STUDENTS' CONTENT LEARNING, CRITICAL THINKING ABILITY, AND ATTITUDE TOWARD SCIENCE

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Jane McAndrews

University of Northern Iowa

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CHAPTER 1

INTRODUCTION

Importance of Science Teaching

The identification of factors which increase science achievement and interest among students is a topic of renewed consideration among researchers. Today educators and societal leaders are deeply concerned that the schools are not producing future scientists, engineers, and a citizenry at large who will be able to deal capably and creatively with a high-technology, post-industrial era in American society. Concomitant with this new technological age are the increasingly critical dilemmas of energy production and use, environmental degradation, world food shortage, and the threat of nuclear annihilation. These problems seem to make the need for a scientifically literate public as well as capable, professional scientists even more obvious. News media commentators speak frequently about the grim outlook for the future because of the present shortage of science teachers whom, they say, are already encouraging fewer students every year to look toward careers in science.

Research (Yager, 1980) indicates that science education is indeed facing a crisis, not only in terms of the declining number of science teachers and students, but worse, because of the inadequate quality of those teachers and the reduced achievements of their students. A careful investigation into the teaching of science is, therefore, a most significant endeavor given the circumstances presented.

Since the major approaches to science education divide into two general orientations, "activity" and "traditional", the present study, conducted by a sixth grade teacher in the Cedar Falls (Iowa) Community School District, was designed to provide data concerning the comparative value of these approaches. In particular, it represents an effort to compare the effects of each approach upon student content learning, critical thinking, and attitude toward science. This study has been done in the belief that a greater understanding of our past and an investigation into our teaching methods can assist elementary educators whose aim is the teaching of science.

Format

This paper consists of two major sections. In the first, an historical perspective, science teaching theory and practice are traced from the mid-nineteenth century to the present. An historical context of the key orientations to science teaching under examination in the present study is provided. The historical perspective is also designed to help clarify these orientations through the presentation of the ideas of writers like Pestalozzi, Spencer, Dewey, and Piaget. Also included is description and background material on the three curriculum projects developed in the 1960's (Elementary Science Study, the Science Curriculum Study, Science--A Process Approach) which were precursors of the activity-oriented textbooks, one of which was used in the research reported upon here.

The second section of this paper consists of the formal report on the study which has been undertaken. This is an investigation comparing the effects of the activity and traditional methods of teaching upon sixth grade students' science content learning, critical thinking ability, and attitude toward science.

CHAPTER 2

ELEMENTARY SCIENCE TEACHING IN HISTORICAL PERSPECTIVE

In the mid-1800's Horace Mann led a crusade to make free, public education available to all. The "great equalizer", as Mann referred to the new schools (Cremin, 1964, p. 9), would secure the strength of American democracy through the education of its citizenry and, in the process, eliminate such societal ills as poverty and crime. At a time when American industry was expanding at a furious rate and immigrants were pouring into the eastern seaport cities, the idea of universal education gained popularity. By 1860 most states had passed compulsory education laws and it was now up to educators to provide programs for the nation's children (Cremin, 1964, p. 13). The roots of modern science education were established in this context.

Influences Upon Science Teaching (1850)

Two important influences upon science teaching can be identified as early as 1850. These influences differed in terms of the perspective taken toward the learner himself, the way in which learning was seen as best achieved, and in the type of curriculum utilized.

The first of these influences was the didactic literature which had originated in England and reflected its aristocratic system of education. The materials, which were designed to be taught at home by a private tutor or by parents, were adapted and published in America for the newly established public schools and represented the first science textbooks (Smith, 1971, p. 38). Educators who ascribed to this curriculum mode generally supported the expository teaching method, which regarded the structure and content of the discipline as presented by the teacher to be of central importance in the classroom setting. Children were seen as being responsible for their own learning and were to demonstrate that learning through verbal or written recitation of the bodies of knowledge presented. Though expository teaching, in the hands of well-skilled teachers, resulted in meaningful learning, frequently, in less-skilled hands, the misapplication of this method resulted in the rote memorization of isolated facts. Within this range from effective application to misapplication, the expository teaching method began to be referred to more commonly as "traditional" teaching.

The second influence on science teaching in the early years of American public education was the Pestalozzian object teaching movement (Smith, 1971, pp. 38-39). Pestalozzi, a Swiss educational reformer, advocated a naturalistic approach to teaching which downplayed the importance of the teaching of abstract concepts and the use of the textbook itself. Instead, the Pestalozzian method emphasized learning through the manipulation of objects within the environment, and regarded the student and his interests as important factors in the classroom setting (Krusi, 1875, pp. 162-164). At a time when the public school was beginning to be envisioned more in terms of a preparatory center for life in a democratic society rather than a highly formalized center of scholarship, object teaching gained a good deal of support among American educators (Cremin, 1964, p. 134).

Borrowing from Pestalozzi, Herbert Spencer became an advocate of object teaching and, in addition, a believer that the duty of education was "to prepare us for complete living" (Spencer, 1963, p. 31). Moreover, he believed that traditional education had lost sight of the most important learning one could pursue and that "elegance" instead of learning for life had become its goal (Cremin, 1964, p. 92).

Spencer took science education a step further, however. He, like many others of his time, was greatly affected by the theory of evolution set forth by Darwin. His views on education reflected that interest. He believed that, as other organisms had adapted to their respective environments, human nature was able to adjust to the circumstances of living (Cremin, 1964, p. 93). And what better way to prepare for living than to utilize one's time in school in becoming acquainted with objects in the environment?

Spencer had linked object teaching and Darwinian thinking in a way which encouraged an interest among American educators both in the discipline of science and its actual application to teaching itself. Spencer's ideas had helped promote science to a level of importance in American education it had not previously occupied.

As a result, a new emphasis in science education upon the use of the laboratory and other direct experiences began to emerge. More emphasis began to be placed upon the discipline of science as a prerequisite for college and upon special training for science teachers (Smith, 1971, p. 40).

Unfortunately, object teaching in America evolved into the practice of having children provide simple descriptions of objects within their environments. It did not call upon their further interpretation and understanding of events and phenomena. The emphasis on observation and memorization by young children was based on the assumption that children were able only to observe and identify objects--not to reason or to interpret phenomena. In addition, the specialized methodology of object teaching, along with the exclusion of the use of textbooks in the classroom, demanded scientific ability and knowledge of the teacher which, in most cases, did not exist (Smith, 1971, p. 39).

Nature Study (1890-1910)

During the late 19th century, rural America had begun to decline in population and prosperity. Cheap land was gone and depression resulted in deepening poverty on the farm. The jobs, the money, and the opportunity had moved to the city, where the Industrial Revolution had spurred the factory system. Droves of young, rural people moved there too. In an effort to stop this flow, educators abandoned object teaching and instituted a new movement--nature study.

Liberty Hyde Bailey led the nature study movement by advocating that learning should stress "rural needs, [be] concerned with rural problems, and seek . . . to cultivate a love of agriculture and the land" (Cremin, 1964, p. 78). Wilbur Jackman, an elementary teacher in Colonel Parker's famous Chicago practice school, was one who implemented nature study by combining Bailey's suggestions with a teaching method based on the process of science. He conducted trips with his students which got them out into the fields and onto the lakesides. Students were to observe, make drawings and descriptions of their trips, and later, carry their investigations back into the classroom. There, laboratory work in physics and biology was conducted by students. Jackman demonstrated how science process could be used as it related to the teaching of nature study (Cremin, 1964, p. 133; Smith, 1971, p. 41).

However, Jackman was not representative of elementary teachers in the 1890's. Most were resistant to school reform and, even if they had demonstrated a zeal for nature study, they were inadequately prepared both in the science of pedagogy and in the knowledge they carried to their station (Cremin, 1964, p. 168). The teacher was cast into an almost impossible role of having to implement a reform movement for which he had little interest or preparation.

Nature study was an outgrowth of object teaching and, like it, was based in part on the principles of faculty psychology which assumed that children could not interpret data, only observe and identify it. However, some basic shifts in the role of the child in the school and in the way in which teaching was to proceed had occurred. A transition from a dependence on European formulations to a newer scientific pedagogy had taken place. Observing, describing, and in some cases, interpreting natural phenomena and objects within the environment became a more frequently used technique in nature study. In addition, the child and his/her interests took a more central position in the schools during this period than ever before.

John Dewey

By the 1920's educators and the society at large began to realize that America was becoming an urban society and that emphasis upon nature study would not stop that from happening. In addition, the influence of the Progressive Education Movement, led by such men as John Dewey, began to influence educators tremendously. Perhaps Dewey's most significant contribution to the development of elementary science was his idea that "learning the methodology of science is at least of equal--or perhaps of greater--value to students than the actual knowledge they accumulate" (Smith, 1971, p. 42). Dewey not only advocated the teaching of science process, but he bitterly criticized the traditional approach to teaching when he stated that science education had too long been "in the teacher, the textbook, anywhere and everywhere you please except in the immediate instincts and activities of the child himself" (Dewey, 1915, p. 51). The child and his interests, according to Dewey, were to assume a central position in teacher planning for, unlike the faculty psychologists who mainly considered the limitations of the child, Dewey believed that even the most limited child had potentialities which could be enhanced.

Thus, Dewey argued, teachers should provide experiences for students which interest them, which relate to their lives, which integrate their learning rather than segregate it into distinct, disconnected subject areas, and which promote a desire to go on learning (Dewey, 1969).

In order for teachers to know which opportunities to use when developing their curricula, which impulses to encourage among their students, and which social attitudes to cultivate, teachers had to possess a thorough knowledge of the disciplines and an awareness of those common experiences of childhood which could be utilized to lead children toward understandings represented by that knowledge. Dewey pointed out that without such abilities, teachers might substitute for traditional curricula, a series of disorganized activities which end up being miseducative (Cremin, 1964, p. 138). The demands upon the teacher were great. In light of the fact that most elementary teachers in the 1920's and 1930's had little more than one year's normal school training it is not surprising that many of them lacked the ability necessary to implement Dewey's theory.

Schools in Crisis (1940-1960)

A swing away from science teaching methods which emphasized the central importance of the learner and a curriculum based upon the experience of children occurred as a result of a more general protest against the Progressive Education Movement which Dewey had led. Following World War II, trained and intelligent manpower to meet the needs of an expanding industrial economy, a shortage of teachers, limited budgetary funds, and a deepening concern over communist expansionism at home and abroad were among the factors which aroused critics of education to protest (Cremin, 1964, pp. 338-339). During the decade of the fifties, Arthur Bestor, an American historian who had taught for a number of years at Teachers College, Columbia, articulated the criticisms of the "life-adjustment" schools when he stated that the ultimate purpose of education was intellectual training through the academic disciplines. Bestor argued that "democratic education differ[ed] from aristocratic education only in the number of persons with whom it deal[t]--not in the values it impart[ed]" (Cremin, 1964, p. 345). Bestor contended that the schools, in attempting to meet every social need, had ended up forsaking their own distinctive function: intellectual training. Bestor reminded educators that "the men who drafted our constitution were not trained for the task by 'field trips' to the mayor's office and the county jail" (Bestor, 1953). Though Bestor's writing represented the most extreme criticism of education during the fifties and was, thus, not taken terribly seriously by most educators of the time, teachers did begin to question the efficacy of the Progressive Education Movement (Perkinson, 1968, p. 93).

This general discomfort with child-centered teaching methods initiated a move by elementary science teachers away from the experience-oriented teaching methods set forth during the progressive era toward content-centered, textbook-oriented approaches. During the 1950's, about 80 percent of the primary teachers and 90 percent of the intermediate teachers based their science instruction on the textbook (Helgeson, Blosser, Howe, 1977). These statistics indicate limited child-centered, activity-oriented teaching methods.

It is interesting to note that in the time span of one century Bestor's ideas had come full circle from the first influences on science education which were discussed earlier in this chapter. Whereas Pestalozzi's object teaching represented a reaction against the narrowness and formalism of the didactic literature of the 1850's, Bestor was now calling upon schools to return to it.

Jean Piaget

At about the time of Dewey, the ideas of a Swiss scientist, Jean Piaget, were being formulated. However, they did not influence elementary science directly until the 1960's. It was during the decade of the fifties that English translations of his later books became available to American educators. Believing that American schools were in need of some revitalization, educators were eager to seek fresh ideas on curriculum planning (Singer & Revenson, 1978, p. 3), and thus became greatly interested in Piaget's studies of how children learn. Though he did not formulate a specific teaching theory, his

> comprehensive . . . theory of childhood and adolescent intellectual development [did] provide educators with clear psychological principles upon which to base curriculum reform and changes in classroom teaching (Henry, 1976, p. 81).

A first principle drawn from Piaget's theory is the view that children are capable of thinking. In contradiction to the faculty psychologists discussed earlier, Piaget found that

> children are capable of proceeding beyond the processes of . . . observation and . . . description into the domain of reasoning, . . . drawing conclusions about causality, and . . . making generalizations" (Henry, 1976, p. 84).

Thus, according to Piaget, one of the goals of science teaching should be to expose children to learning experiences that are intellectually demanding for the children within the parameters of their development (Henry, 1976, p. 85).

One can hardly consider the implications of Piaget's theory for teaching without being reminded of Dewey. Like Dewey's, Piaget's theory implied a child-centered, experience-oriented, developmentally sequenced teaching approach. This comment, made by Piaget in 1964, is reminiscent of Dewey:

> As far as education is concerned, the chief outcome of this theory of intellectual development is a plea that children be allowed to do their own learning . . . You cannot further understanding in a child simply by talking to him. Good

> pedagogy must involve presenting the child with situations in which he himself experiments. (Duckworth, 1964, p. 2)

The implications of Piaget's theory for the method of teaching science were discussed widely by educators. Modgil (1974, p. 273) stated that Piaget's views in connection with science teaching "centre around the importance of active methods." According to Henry (1976, p. 85), "a science curriculum which is child-centered and also inquiry-oriented would probably satisfy Piaget's dictates."

The ideas of psychologists like Piaget clearly suggested that "process" or "inquiry" methods, which implicitly involve the active participation of students, should be stressed in elementary science classes.

The New Curriculum Projects (1960-1980)

The 1957 Russian launch of the space satellite, Sputnik, resulted in a great deal of soul searching on the part of American educators. As if the lambasting criticism, articulated by Bestor, was not enough to bring into question the efficacy of American education, the perception by the public of Russian technological superiority seemed to imply that the schools and professional educators had failed completely. As a result, science educators sought new direction in curriculum planning through the theories of developmental psychologists like Piaget, as well as the suggestions of professional scientists. With the help of massive funds from the federal government, the National Science Foundation (NSF) supported the development of several new elementary curriculum projects. The three major ones were Elementary Science Study (ESS), the Science Curriculum Improvement Study (SCIS), and Science--A Process Approach (SAPA).

ESS represented the least structured of the three curricula. The program philosophy stressed guided discovery as the best way for teaching to proceed.

The program was organized into 56 independent units with no fixed sequence across the elementary grades. Life and physical science units were included as well as several units involving activities in spatial relations and logic and perception. Activities were included both for their motivating quality and for the opportunity they provided for problem solving and understanding of natural phenomena. Activities were often begun with a challenge problem or perplexing event, followed by a period of open-ended exploration and concluded with class discussion (Bredderman, 1982).

The primary goal of the SCIS program was the development of scientific literacy, defined by Karplus (1964, p. 301) as a "combination of basic knowledge concerning the natural environment, investigative ability . . . and curiosity." Heavily influenced by the theory of Piaget, the concepts presented in the program were interrelated and intended to provide a conceptual framework for the child's thinking. Opportunity was provided for developing science processes as well. The general instructional pattern was to allow for free exploration of new materials, to introduce or "invent" a new concept, and then to allow the new concept to be applied in a range of new situations (Bredderman, 1982).

SAPA was the most highly structured of the three curricula and its goal involved teaching science through specific science processes. SAPA organized concepts into small instructional steps which were expressed in behavioral terms and sequenced in a hierarchial arrangement. These concepts were drawn both from the physical and life sciences. The particular concepts were selected primarily because they presented clear situations in which a process step being taught could be applied (Bredderman, 1982).

Though each of these programs had different areas of emphasis, they shared a common set of departures from the traditional programs available during the fifties. Smeraglio and Honigman (1973) summarized the distinctive traits of the new program:

1. They . . . resulted from collective efforts of scientists, teachers, administrators, and developmental psychologists.

2. Psychological principles of cognitive growth and development [were] used as guidelines.

3. They were activity-oriented, reflecting direct psychomotor experiences.

4. They [were] process oriented.

5. They contain[ed] "kits" of materials for students.

6. There [were not] texts for students, only teacher manuals and guidelines.

The ideas of Pestalozzi, Jackman, Dewey, and Piaget were threaded into the new curriculum project goals. So, too, were the suggestions of Bestor. Though certainly activity-oriented, these programs were organized to lead children, through training in critical and disciplined thinking in each of the processes of science, to the generalizations of the discipline of science. Though the child remained a fairly central figure in the planning of the curriculum in that his developmental growth was considered, the content was not subject to his special interest--it was specifically set. The projects were content-centered and content-based.

In addition to the development of new curricula, motivation for reform resulted in

> thousands of teachers flock[ing] to college campuses for refresher courses in science and mathematics and attend[ing] inservice classes [sponsored by the National Science Foundation]. In 1963 alone, there were 412 federally funded inservice institutes with a total enrollment exceeding 21,000 teachers (Kyle, Shymansky, Alport, 1982).

The new curriculum projects caught on and, throughout the 1960's, a growing acceptance of them emerged (Atkin, 1969, p. 1194).

Problems of the 1970's

Times changed, however. The boom of the 1960's slowly dissipated in the 1970's. The oil embargo in 1973 and the economic difficulties which followed strained school budgets and squeezed moneys intended to replenish science curriculum materials. Also, the bulging school enrollments of the 1960's gave way to declining enrollments in the 1970's, resulting in still further limitations on science education budgets. A diminishing resource base, local program cutbacks, and new federal budgeting priorities contributed to many departures from the use of the "new" curriculum projects (Yager, 1980). In the late 1970's, research (Weiss, 1978) reported that of the 33 percent of districts in the country which had reported that they used ESS, SAPA, or SCIS, only about one-fourth of the schools and one-fourth of the teachers within those districts said they used the curriculum projects. Teachers and schools were returning to the textbook as the basis for their science curriculum (Yager, 1980; Weiss, 1978). And why not? The ongoing expense of an activity-based program was far more than the one-time expense of textbooks. Thus, economic necessity played a part in the decline of the use of the curriculum projects.

Economic hardship was not the only reason the enthusiasm for the new science curricula lost its steam. Many people came to believe that the curriculum development projects had failed, that students neither learned more nor did better in these activity-based, process-oriented programs than they had in traditional textbook-based classrooms (Kyle et al., 1982). In fact, it was shown that they had done worse! A general decline in student achievement test scores was reported to be a national problem. The National Assessment of Educational Progress results continued to show declines in general scientific literacy, and, except for students who were planning careers in science, the SAT scores showed that the great majority of students were learning less and less science (Butts, 1982, p. 1669).

A reaction to the decline in student achievement scores was the growth of the "back-to-the-basics" movement (Butts, 1982, p. 1670; Yager, 1980). Its advocates charged that schools had pandered to students by offering "frills" at the expense of basic literacy in reading, writing, and mathematics. The public perception that elementary school standards were declining so that any student could succeed and thus "feel good about himself" resulted in public criticism of almost any school activity which did not limit itself to intellectual skill building. Since science was not considered a "basic" in the way that mathematics and reading were, teachers gave it low priority (Butts, 1982; Helgeson et al., 1977). With the pressure of this movement, science had largely become a "forgotten" subject in the elementary school not because anyone was consciously trying to exclude it, but because no one seemed to be interested in supporting it (Butts, 1982, p. 1670).

Another reaction to the declining national test scores was the insistence by many societal leaders that teachers "account" for what they did in the classroom (Helgeson et al., 1977). Hard evidence of academic achievement in the form of improved scores was demanded. The curriculum projects' evaluation process was, in contrast, generally done relatively informally, through the observation of children during instructional activities rather than through pencil and paper examinations (Bredderman, 1982). This type of evaluation was less reliable and more difficult to interpret than the percentages or grades provided by objective tests. The public seemed to want "numbers"--a further blow to the curriculum projects.

In addition, the elementary school day itself presented an obstacle to teaching the activity-based programs. A plethora of daily duties and interruptions ranging from school assemblies to curricular requirements such as career education, were to be squeezed into the school day along with science, reading, mathematics, social studies, spelling, language arts, music, physical education, art, talented and gifted classes, chorus rehearsal, instrument lessons, computer time, etc. According to research (Anderson, 1980), the average amount of time spent in the teaching of science in Iowa elementary schools ranged from 44 minutes per week in first grade to 115 minutes per week in the sixth grade. These numbers do not differ greatly from those found by Blackwood (1965) 15 years earlier. His research indicated that the national weekly average of time spent in science teaching in the elementary grades ranged from 57 minutes per week in first grade to 110 minutes in sixth grade. According to Elkind (1974), children need a block of time in which they can work at science intensively. "We destroy the potential of creativity by not providing this uninterrupted time" (Elkind, 1974, p. 27). Obviously, the elementary school day as the author has described it, makes uninterrupted time--time to think and consider, reflect, question, and hypothesize--a luxury most elementary students and teachers do not enjoy.

As if the decline in economic support for the activity-based programs, the decline in student achievement scores, the "back-to-the-basics" movement, the accountability movement, and the lack of time during the school day to teach science were not enough to destroy the curriculum projects, teachers themselves represented a major factor in their decline. While, as indicated earlier, NSF did offer intensive training classes in the 1960's and early 1970's, the majority of today's teachers have not participated in them (Helgeson et al., 1977; Weiss, 1978). In addition, the general wearing-out of kits, loss of items within the kits and the difficulty in obtaining the kits as a result of having to share materials among schools made using the programs a major effort to organize (McCalley, 1983).

In addition, most elementary teachers lack adequate background in the discipline of science. In a 1973 report (Williamson, 1973) to a Standing Conference on School Science and Technology (SCSST) symposium, in which nine colleges of education were investigated to find out which courses prospective teachers were pursuing, it was noted that only 5 percent of those intending to be elementary teachers followed a mathematics or science main course as against 75 percent liberal arts and 10 percent physical education. In a 1977 national survey (Weiss, 1978), only 22 percent of the elementary teachers reported feeling "very well qualified" to teach science and a considerable number of elementary principals, in a position to aid teachers in the classroom, indicated that they were "not well qualified" to supervise science instruction. The author has shared this feeling of inadequacy, having had only one general science course in her undergraduate program and no in-service training on the new curriculum projects, one of which she was assigned to teach during her first year out of college. It seems only common sense to expect that one who knows little of a subject area cannot easily teach it, let alone teach it with insight and enthusiasm.

Implications for the Present State of Science Teaching

The decline in support for the new curriculum projects of the 1960's resulted in a gradual return to traditional teaching approaches. Research indicates (Helgeson et al., 1977) that though there has been an increase in student-centered and "hands-on" instruction since 1955, a substantial percentage of students during the late 1970's were not being taught with such procedures. Only about one-third of the K-6th grade teachers reported utilizing manipulative material at least once per week in their classrooms and far fewer (7-11 percent) reported using them daily (Weiss, 1978). The decline in the use of such activity-oriented teaching approaches was predicted to continue as the number of teachers using one textbook in their classrooms continued to increase (Yager, 1980). And it has been increasing!

The NSF status studies suggest that school programs can be described in a single word--"textbooks" (Yager, 1980). Gega (1980) suggested that the dominant way of teaching science in 1980 was through textbook programs. Research reports (Weiss, 1978) that between 40 and 56 percent of the elementary classes in the country utilized one basic textbook series in their science program.

However, though the textbook is becoming more and more prevalent in elementary science classrooms, it is not the same sort of book it was in 1955. Gega (1980) suggests that the curriculum projects of the 1960's have influenced the orientation of the new textbooks. He notes that these books contain many more opportunities for students to use "hands-on" activities than textbooks of the past. In these current texts, there is more emphasis placed upon process skills. Concepts and vocabulary are more likely to be geared toward the students' cognitive levels and when activities raise questions, the background necessary to answer them is more likely to be found in the teacher's manual. It seems to the author that these new textbooks seek to provide both the emphasis upon content preferred by the traditional educator and the "hands-on" experiences desired by the activity advocates.

Thus, there are opposing views of science teaching which have evolved in response to historical circumstances. These responses led to an emphasis upon one or the other of these orientations, depending upon which one happened to be in use at the time.

There seems to be a great deal of support among researchers and theorists for an activity-based approach. Pestalozzi, Spencer, Jackman, and Dewey seemed to know, through insight, the importance of active participation among students as an important aid to learning. Piaget provided data which very strongly favored the use of active methods in the classroom.

Times change and historical circumstances prompt desire for educational reform. Now is one of those times. Present economic, political, and environmental problems have provided a renewed emphasis upon the importance of science as a discipline which must somehow be taught to the nation's children.

Historical Background Summary

An historical perspective upon science teaching in America from the 1850's to the present suggests that as early as the mid-1800's, educators like Pestalozzi and Spencer believed that children learn more through their manipulation of objects in the environment than through the memorization of facts from textbooks. Their work represented a first step toward the activity-based science projects that arose in the 1960's.

The nature study movement, led by Bailey, is further evidence that activity-based science had its roots deep in the past. Getting children outside to observe and describe everyday surroundings was as important a procedure then as it was during the "innovative" 1960's.

Dewey was the father of activity-based, process-oriented science teaching. His beliefs about teaching and learning are the antecedents of those of today's proponents of a process approach to science teaching. In addition, he, more than anyone before him, espoused the view that learning proceeds best when the interests of the child are appealed to in the classroom environment. That idea has been studied for years and is a cornerstone of the humanistic psychology in education today.

The work of Jean Piaget provided data about children and how they learn, which gave process-activity-oriented science advocates something besides rhetoric upon which to act. Piaget's theory of cognitive development was the groundwork upon which several of the curriculum projects of the 1960's were based. After all the argument over whether or not the procedures advocated in object teaching and nature study, and the ideas set forth by Dewey were "just theory", it seemed that advocates of an activity-based, process-oriented approach to teaching science finally had the hard evidence they needed.

When Sputnik was launched, money for science teaching became plentiful and science educators found themselves in the middle of a "golden age." New NSF curriculum projects were developed and implemented. Everyone seemed so sure they would work that researchers hardly questioned them (Butts, 1982).

Of course, as time went on, problems with the new materials began to surface. Times changed and so did priorities. Money was getting harder to come by, the public was growing tired of declining national test scores and allegedly unqualified graduates, and teachers began to question whether or not these curriculum projects were really effective or practical. Were they practical given the demands of the elementary school day, given the decline in the number of teachers who had been trained to use them, and given the difficulty of finding, repairing, and replacing their parts?

The decade of the 1970's provided evidence that teachers began to pull back from the curriculum projects and also the methods and ideas behind them. Traditional teaching methods and textbooks seemed the only alternative to the methods and materials needed to implement the NSF curriculum projects.

But 1980 presented educators with new challenges which demanded a change in the methods of science teaching. Given the recent state of American political, educational, and environmental problems as described in Chapter 1, science has again begun to receive a great deal of national attention. It is in this context that science educators, having examined all possible approaches to science teaching, have developed textbooks which combine aspects of both the traditional and the activity methods. And today, more and more of them are being used in the schools.

As a result, the urge to teach science by providing opportunities for students to manipulate objects in their environments, to get out into the world of nature, to question, investigate, hypothesize, and become involved and interested in their work has, in today's atmosphere, returned to some prominence.

CHAPTER 3

THE PROBLEM

The advent of new, activity-oriented textbooks which emphasize the teaching of science through the use of an activity method while providing textual information which can be read and discussed through a teacher-directed method suggests a bonding of the two approaches traced in Chapter 2. Neither purely activity nor purely traditional, this type of curriculum provides the teacher with a specifically defined structure through which to work and sets of pre-planned, "hands-on" activities for use with each topic. In order for both the activity and the content goals of the new programs to be met it is suggested by the curriculum authors that all components of the particular curriculum be utilized by the teacher. If the activity component of these new programs is not utilized, then chapter reading, discussion, and writing assume the major focus of the lesson plan. The utilization of the activity component results in combining chapter reading and discussion with the manipulation of materials during science class. The author's own experience indicates that various teachers approach a particular science topic by having students read, recite, and review chapter content, while others instead assign students to perform experiments and use the textbook largely as a reference.

It is these two opposing approaches to teaching science, traced historically in Chapter 2, which have been investigated here. More specifically, whether or not differences in student content learning, critical thinking, and interest in science will result from the utilization of one or the other of these two teaching methods are questions the author has investigated in the present study.

Statement of the Problem

The purpose of this study was to determine whether or not students would perform as well on the tests included in the Accent on Science (Sund, Adams, Hackett, 1980) program and show as positive an attitude toward their science study if the activity component in the program was not utilized as would those students being taught the same content with the benefit of the activity component. More specifically, the following research hypotheses were tested:

1. Students who study the topics of "mixtures" and "acids and bases," as they are presented in the program Accent on Science (Sund et al., 1980) through an activity approach, will score significantly better on tests of factual knowledge and critical thinking than students who study the same concepts, presented in the same program, through a traditional approach.

2. Students who have received activity-oriented instruction will show significantly more positive attitudes toward the study of science than will the students who received traditional instruction.

Significance of the Study

Though a number of studies have been performed comparing the activity approach with the traditional approach to teaching science as they relate to two different educational programs, fewer attempts have been made to compare the two teaching approaches as they relate to just one program.

With the growth of new, activity-oriented textbooks, and the resultant option for teachers to use either method, the results of this study, it is hoped, will give teachers information regarding the likely effects of their own approaches to the new textbooks upon student content learning, critical thinking, and attitude.

Limitations of the Study

The study was undertaken with the following limitations:

1. Only 70 subjects participated in this investigation. This limited population may restrict generalizability of the findings.

2. Subjects were not randomly selected. It was necessary to use intact classrooms. Also, within each intact classroom, two groups were established, the activity group and the traditional group. The subjects making up each group were matched according to sex, IQ, and Iowa Tests of Basic Skills (ITBS) science subtest grade equivalent score in order to equalize, as much as possible, those variables between the two groups.

3. The instruction/treatment period totalled only 15 class sessions. This rather limited treatment period may not be sufficient to determine real differences in student achievement and attitude. Furthermore, after the first treatment period of 7 sessions, the groups were reversed so that each received the opposite treatment during the last 8 sessions. This may have created multiple treatment interference in the second experiment.

4. The interest survey was given immediately following the first and again following the last treatment period. A threat to testing may jeopardize internal validity.

5. The instruction/treatment was administered by only three teachers, one of whom was the researcher. This limited population may restrict generalizability of the findings.

Definition of Terms

For clarity, these six terms require definition:

1. Activity Approach refers to that teaching method or curriculum philosophy which emphasizes the processes of science (i.e., observation, measurement, classification, inference), and which emphasizes higher cognitive skills (i.e., analyzing, predicting, evaluating, hypothesizing, inferring, deducing, interpreting data, imagining, and synthesizing) by integrating laboratory activities into course reading and discussion.

2. Traditional Approach refers to that teaching method or curriculum philosophy which emphasizes the learning of scientific facts, laws, and theories through the reading of textbook material and through listening to and/or participating in teacher-directed discussion.

3. Hands-On Activities refers to those activities by which students are expected to learn by manipulating materials rather than by reading, listening, or participating in discussion.

4. Science Process refers to the method by which scientists engage in their investigations. Such skills as observing, measuring, classifying, and inferring are aspects of this method.

5. Critical Thinking refers to the following behaviors, according to Eisner (1965):

"Drive and curiosity" is defined as the desire to interact with the environment, to pursue knowledge, to raise questions, to formulate ideas and images of what might be, and use information to make "educated guesses."

"Creative intuition" is the ability of students to use past experience to learn some new idea.

"Evaluating" is described as the ability to use logic and to be concerned with evidence.

"Constructing" is defined as the ability to see relationships between seemingly unrelated concepts and to perceive elements as part of a larger whole.

6. Attitude refers to the interest in science indicated by students, their feelings about the science activities actually performed, and their perceptions of the amount of learning they achieved.

CHAPTER 4

REVIEW OF RELATED LITERATURE

Introduction

The purpose of this chapter is to provide a review of the research which has been done regarding the activity and traditional methods of teaching science (1) as it affects student content learning, (2) as it influences critical thinking, and (3) as it relates to student attitude.

A large number of studies cited in this review were included in analyses and meta analyses of research. Therefore, much demographic information is not included. However, all studies do include American elementary students as subjects.

Content Learning

A frequent criticism of activity science has been that too much stress has been focused upon science process at the expense of science content learning (Atkin, 1966; Ausubel, 1963; Fishler & Anastasiow, 1965; Labahn, 1966). In order to either verify or dispel this criticism, a great deal of research has been done to compare the achievement scores of students who have been taught through an activity method with those who have been taught through more traditional methods. The following studies represent some of that research.

Perhaps the most comprehensive collection of research on activity science in the elementary school was gathered and presented by Bredderman (1982). He did a meta analysis of 57 studies done over the prior 15 years which resulted in 400 separate comparisons involving 13,000 students from

1,000 classrooms. These studies were concerned with the effects of three activity-based science programs: Elementary Science Study (ESS), Science Curriculum Improvement Study (SCIS), and Science--A Process Approach (SAPA). In each study, classrooms using one of the activity-based programs were compared with classrooms comparable in other respects, but using textbooks or other traditional ways of teaching science.

Bredderman (1982) found that the activity-based science programs were, indeed, most successful in the area of science process skills. It was found that, on the average, children in activity-based science programs performed 20 percentile units higher than comparison students. In other words, if the average student in the traditional group performed at the 50th percentile on tests of science process, the average student in the activity-based classroom performed at the 70th percentile. These results were based upon 26 different studies (Allen, 1967, 1970, 1972, 1973a, 1973b; Barksdale, 1973; Beard, 1971; Billings, 1976; Bowyer & Linn, 1978; Bredderman, 1974; Bullock, 1972; Cleminson, 1970; Jacknicke, 1975; Judge, 1975; Linn, 1972; Linn & Peterson, 1973; Linn & Thier, 1975; Mansfield, 1978; Maxwell, 1974; McGlathery, 1968; Partin, 1967; Ransom, 1968; Riley, 1972; Schmedermann, 1969; Somers & Lagdamen, 1975; Wideen, 1975).

On tests of science content, activity-based science students averaged only about 6 percentile units higher than the comparison group. Thirteen studies were compiled to produce these results (Billings, 1976; Blomberg, 1974; Bowyer & Linn, 1978; Davis, Raymond, MacRawls & Jordan, 1976; Jacknicke, 1975; Linn, 1972; Long, 1973; Novinsky, 1974; Partin, 1967; Raven & Calvery, 1977; Riley, 1972; Smith, 1972, Wideen, 1975).

The effects of the activity-based programs as reported in this meta analysis were significantly higher on tests of science process, but only modestly higher on tests of science content.

Other individual studies have found that activity-based science teaching results in significantly greater student content achievement.

A study compared 321 fourth grade students in 4 Honolulu, Hawaii schools. One-half the students were taught science through a "textbook-recitation method" including neither demonstration nor experimentation. The other one-half were taught with a "problem method", based upon demonstration and experimentation. It was found that the achievement gains of the problem method group were significantly greater than for those of the textbook recitation group (Carpenter, 1963). Several other investigators contrasted the teaching of science content using particular aspects of activity-based approaches with more traditional methods. Generally, they found that the activity-based methods produced greater science content learning than did the traditional method (Davis, 1978; Marlins, 1973; Voelker, 1975; Vongchusiri, 1974).

Other researchers did not find significant differences in student content learning between textbook methods and activity methods. In a study of 110 third and fourth graders from a rural school district south of Rochester, New York, students were assigned randomly to either an activity-based curriculum, or one of the new activity-oriented textbook programs. The results suggested that neither teaching method nor materials made a significant difference in classification ability or science achievement (Vanek & Montean, 1977). In an investigation comparing the merits of using a mobile science laboratory which emphasized active student participation in the basic scientific procedures of experimenting, classifying, measuring, and observing to the traditional method of reading and discussing text content, it was found that neither method produced significantly higher test scores in science achievement (Miller, 1967). In other work, a traditional textbook method was compared with a method utilizing a specially designed board to teach electricity and magnetism (Gerne, 1967), and a field method was compared with a classroom method for teaching ecology (Bennet, 1965). Neither researcher found significant differences in student achievement.

From these studies it is difficult to conclude that activity-based science is any more effective in increasing student content achievement than traditional textbook methods. The findings are inconclusive and contradictory.

Critical Thinking

One of the major goals of activity-oriented science involves the development of critical thinking skills. A 1961-62 survey (Blackwood, 1965) of elementary teachers' priorities indicated that helping students learn to think critically was considered "very important" by 85.2 percent of those polled. The authors of Accent of Science (Sund et al., 1980), the curriculum program which the researcher used in this investigation, not only discuss critical thinking in the teacher manual, but include a test which they claim will measure the students' ability to think critically in their evaluation program.

Bredderman (1982) included these three aspects of critical thinking--creativity, perception, and logical development--among the items measured in his meta analysis.

The findings provide evidence that students in activity-based science programs do earn higher percentiles on tests of creativity, perception, and logical development than do students in traditional programs. On tests of creativity, based upon five studies (Davis, Raymond, MacRawls & Jordan, 1976; Fick, 1976; Huntsberger, 1976; Novinsky, 1974; Ransom, 1968), students in activity-based programs showed a 16 percentile gain over traditionally taught students. On tests of perception, from 5 studies (Ayers & Mason, 1969; Battaglini, 1971; Kellogg, 1971; Maxwell, 1974; McGlathery, 1968) and on tests of logical development from 9 studies (Bowyer & Linn, 1978; Bredderman, 1974; Cleminson, 1970; Hansen, 1973; Howe & Butts, 1970; Labinowich, 1970; Linn, 1972; Long, 1973; Raven & Calvery, 1977) the benefits of being in an activity-based program were about 10 percentile units (Bredderman, 1982).

In other investigations it was found that SCIS students were better logical thinkers than were students not involved in SCIS (Linn & Thier, 1975), and SAPA students were found to score higher in creativity tests than were students who used textbooks (Penick, 1976).

In a survey of research on science instruction (D'Angelo, 1971), it was suggested that the traditional approach to science teaching does not foster critical thinking, and in a 1969 analysis of research (Ramsey & Howe, 1969) it was suggested that greater gains in improving creativity can be brought about through problem solving or inductive methods than through traditional approaches.

Student Attitude

Many educational researchers have tended to direct their investigations toward finding out what students have achieved. A lesser investigated, though not less important consideration of any science teacher or program, is the attitude of students. Positive attitudes of students toward science class may be of greater and more lasting importance to the future of their science learning than measures of their present achievement. Certainly Pestalozzi and Spencer believed that student interest was an important factor in learning. Dewey went even further by advocating that the child's interests should assume a central position in teacher planning. And like Dewey, Piaget found that children's interests are paramount in the learning process (See Chapter 2). It was reported that students who fail to have a positive experience in science during their elementary years will take only minimal science courses during junior and senior high school (Butts, 1982, p. 1667). In addition, researchers have found that the critical ages at which pupils' attitudes toward science can be influenced extend from about 8 years of age to about 13 or 14 (Brandwein, 1951; Moore, 1962; Perrodin, 1966; Zim, 1941). More recent evidence (Taylor, Christie, Platts, 1973) goes even further by showing that children taught in schools with good or very good equipment and laboratory space for early work in science are more inclined to opt for science later on.

Following is a group of studies which investigate the attitudes of elementary students toward science.

In a meta analysis of 14 individual studies (Allen, 1972; Barksdale, 1973; Brown, 1973; Hofman, 1973; Jacknicke, 1975; Johnson, 1974; Kolebas, 1971; Krockover & Malcolm, 1977; Linn & Thier, 1975; Lowery, 1980; Novinsky, 1974; Partin, 1967; Riley, 1972; Wideen, 1975) comparing students in activity-based science programs with students in traditional programs, it was found that students in activity-based programs scored 11 percentile units higher on tests of attitude than students in traditional classrooms (Bredderman, 1982).

In another study (Simmons & Esler, 1972) comparing the attitudes toward science of 132 sixth grade students instructed in the "process approach", it was found that those children instructed in the process approach indicated a substantially more positive attitude than did the textbook group. One-half of the children in the process group indicated that they were at ease during science lessons while only 18 percent of the textbook group reported the same feeling. More than one-half of the process group reported feeling successful in science compared to 29 percent of the textbook group who reported such feelings. When asked if it was fun to solve problems in science, 64 percent of the process group said "Yes", compared to 38 percent of the textbook group. Almost 60 percent of the process group thought science was fun and only 5 percent of them said it wasn't. This compares to 39 percent of the textbook group who said science was fun and 15 percent who said it wasn't.

In another study (Jaus, 1977), it was reported that activity-oriented science improved not only children's attitudes toward science, but their attitudes toward school as well. Other research (Vanek & Montean, 1977) found no differences in attitudes between students using activity-based science and those using textbooks. However, the textbook program used in that investigation emphasized the "inquiry approach" and utilized activity in the classroom. The only difference in the two approaches studied was reported to have been that the activity method was student-directed while the textbook method was teacher-directed.

The research presented indicates that student attitudes toward science are more positive among those taught using active methods than the attitudes of students instructed in a more traditional setting.

Summary

In summary, a review of the literature reveals that activity-based science teaching seems to increase student scores in tests of science process, critical thinking, and student attitude. Science content outcomes did not show significant differences overall when activity-based programs and methods were compared to textbook programs and methods.

CHAPTER 5

METHOD

Experiment I

Local Context of the Study

The Cedar Falls (Iowa) Community School District, the district in which the author has conducted this study, has a total student population of 5,322, and an elementary population of 2,676. The district employs 306 teachers. One hundred forty of them are elementary teachers presently assigned among 8 elementary schools. This district is located in northeast Iowa, in a city of about 30,000 people, many of whom are affiliated with the local university or one of the several local factories of an international farm implement manufacturer.

The school district has encouraged activity science teaching by including within its present curriculum the activity-oriented textbook, Accent on Science (Sund et al., 1980). Because the author is presently involved in using this curriculum material, it is her special interest in it which has motivated this study. It is hoped that the investigation presented here will be of use to elementary teachers in the Cedar Falls Community School District, to the district itself in its continued evaluation of its curriculum offerings, and to any other educators whose interest is the improvement of science teaching.

Subjects

Subjects for this investigation consisted of all 70 sixth grade students in a Cedar Falls, Iowa public elementary school. The group consisted of 31 boys and 39 girls in three self-contained classrooms. The students were assigned to their respective classrooms by the school's principal on the basis of maintaining (a) a one-to-one sex ratio and (b) a hetrogeneous mix in terms of reading and general cognitive ability within each classroom.

In each class, the students were divided into two groups that were reasonably matched according to sex, IQ (Kuhlemann-Anderson) and the science subtest grade equivalent score on the Iowa Tests of Basic Skills (See Appendix K for group matching procedure). Twenty-one girls and 15 boys, with an average IQ of 122 and an average ITBS science grade equivalent score of 72, made up the activity group. The traditional group included 16 boys and 18 girls with an average IQ of 120 and an average ITBS science grade equivalent score of 74.

Instrumentation

The Cedar Falls (Iowa) Community School District recently adopted a new elementary curriculum developed for the elementary grades by the Merrill Publishing Company. Accent on Science (Sund et al., 1980) consists of student textbooks, a supplemental activity book, a teacher manual, and an evaluation program. This program is one of the newly developed textbook-based approaches influenced greatly by the NSF-sponsored curriculum projects of the 1960's (See Chapter 2). Moreover, the program was developed by the authors to incorporate in a textbook the theory and activity orientations of those curriculum projects. Toward that end, the program is activity and process-oriented.

The content material and activities utilized in this investigation were taken from Unit Three, Chapter Two of Merrill's Accent on Science 6 (Sund et al., 1980), "Matter and Mixtures."

Content Learning. The test which was used to measure factual knowledge was taken from the Evaluation Program for Accent on Science 6 (Trowbridge & Sund, 1980). This test, hereafter referred to as "factual test 1" (Appendix C), was designed to measure primarily lower-level thinking processes (i.e., observing, classifying, recalling, measuring, and comparing) and consists of 6 multiple choice, 10 recall, and 7 true-false items.

Critical Thinking. The measure of critical thinking, hereafter referred to as "critical thinking test 1" (Appendix D), was designed to test primarily higher-level thinking processes (i.e., analyzing, predicating, evaluating, hypothesizing, inferring, deducing, interpreting data, imagining, and synthesizing) and consists of 7 essay-type and 5 identification items.

Neither factual test 1 nor critical thinking test 1 specifies a time limitation for its completion; however, both tests were completed by all subjects during one 50-minute class period.

Attitude. In an effort to determine student interest in science, and student feelings regarding activities performed and achievement gained, the author constructed a science attitude survey (Appendix H). Some questions in this survey were borrowed from "A Scale To Measure Attitude Toward Any School Subject" (Remmers, 1960) and the rest were developed by the author. Three responses to each statement were possible: (1) agree, (2) no opinion, or (3) disagree.

Procedure

The three participating teachers, one of whom was the researcher, reviewed the 7 lesson plans (Appendix A) which they would be using in their instruction. They implemented the lessons and, according to their statements, administered them exactly as directed and limited each lesson to 50 minutes per day.

Both the activity and the traditional groups were taught the content included in "Matter and Mixtures." The activity group joined the traditional group in class discussion sessions and, in addition, performed the hands-on activities included in the chapter as part of their study. The traditional group, on the other hand, did not perform the hands-on activities, but instead, were given "seatwork" activities, suggested in the teacher manual (Sund et al., 1980). These students used information provided in the student text and vocabulary words as the basis for their activities. In addition, the traditional group was assigned to write out the answers to the questions at the end of each chapter.

Except for the whole group teacher-directed content discussions, the specific directions given to students at the outset of each treatment period, and the separately conducted culminating discussions of work completed during the treatment period, the teacher moved about the room and answered any questions regarding directions given, encouraged students to continue working, and asked questions of individual students as their work proceeded. Students were instructed to work on their assignments only during the treatment period.

Upon the completion of the 7 sessions of treatment, factual test 1 and critical thinking test 1 (See Appendices C & D) were administered to all 70 subjects. All tests were evaluated by the researcher, using the scoring key included in Appendix G. A complete listing of the raw data from both tests is included in Appendix L.

The following day, the attitude survey (See Appendix H) was administered verbally to all 70 subjects in their 3 separate classrooms. Students were directed to respond to each of the 18 items in this way: "Mark 'T' if you agree with the statement, mark 'O' if you have no opinion either way regarding the statement, and mark 'F' if you disagree with the statement." The attitude survey was evaluated on the Harris computer and used the scoring procedure included in Appendix N. A compilation of the raw data generated by the attitude survey is included in Appendix M.

Results

Content Learning. Figures 1 and 2 show the histograms of the percentage scores and Table 1 contains the means and standard deviations of the activity and traditional groups on the test of factual knowledge. This test had a "ceiling effect" with the major difference between the two groups being in the tail. The "t" value is significant at the .05 level.

Contrary to the first hypothesis, the mean of the traditional group exceeded that of the activity group by a statistically significant difference.

Critical Thinking. Figures 3 and 4 show the histograms of the percentage scores, and Table 2 contains the means and standard deviations of the activity and traditional groups on critical thinking test 1.

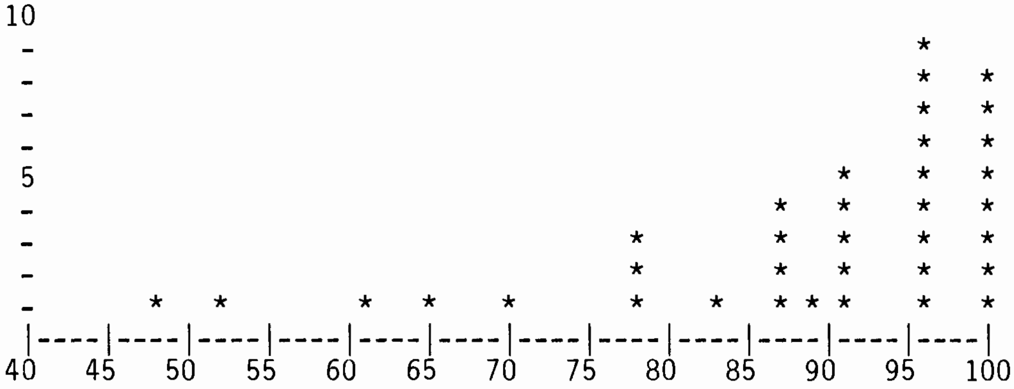
Contrary to the first hypothesis, that the activity group would score significantly better on the measure of critical thinking than the traditional group, no significant difference was found.

Attitude. The histograms, Figures 5 and 6, and the means and standard deviations, Table 3, indicate that no significant difference was found in student attitude. The findings do not support the second hypothesis, that the student attitude of the activity group would be more positive than the attitude of those in the traditional group.

To ascertain the reliability of the test, coefficient alpha was run. Coefficient alpha = 0.78. Further information regarding reliability is included in Appendix I.

FIGURE 1

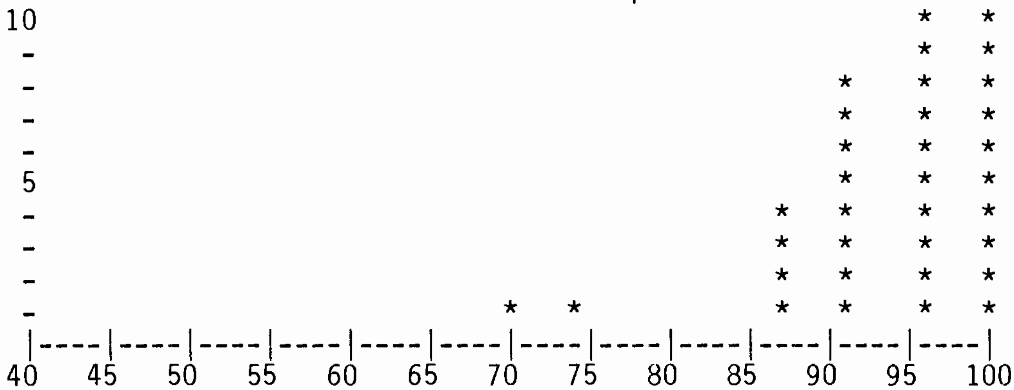
Histogram of Percentage Scores on Factual Test 1
Activity Group



Mean = 88.03   Std. Dev. = 13.71   Sample Size = 36

FIGURE 2

Histogram of Percentage Scores on Factual Test 1
Traditional Group



Mean = 93.53   Std. Dev. = 7.04   Sample Size = 34

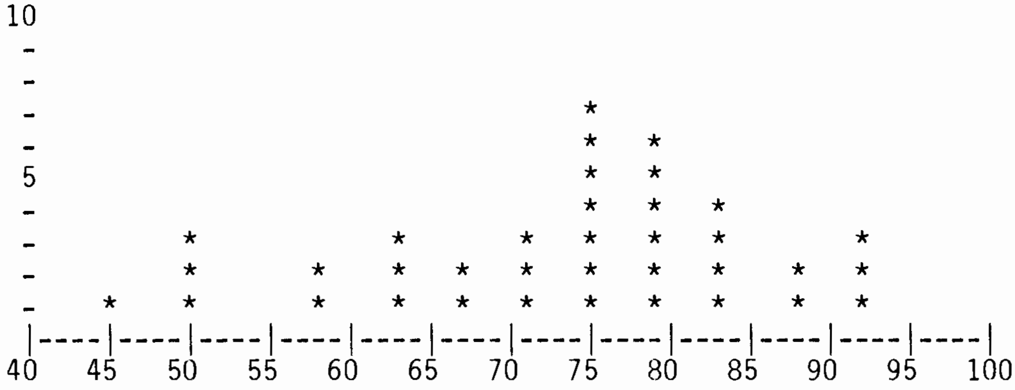
TABLE 1

Results of Factual Test 1

Group	N	Mean	Standard Deviation	t	Alpha
Activity	36	88.03	13.71	-2.09	0.04
Traditional	34	93.53	7.04		

FIGURE 3

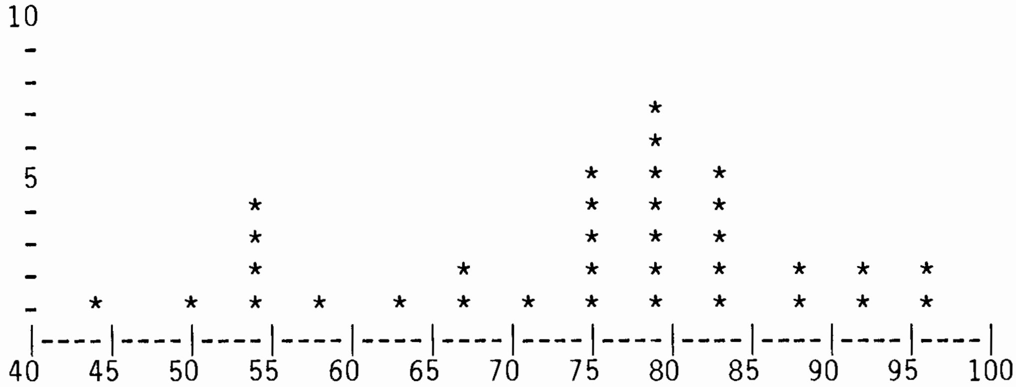
Histogram of Percentage Scores on Critical Thinking Test 1 - Activity Group



Mean = 73.08 Std. Dev. = 12.34 Sample Size = 36

FIGURE 4

Histogram of Percentage Scores on Critical Thinking Test 1 - Traditional Group



Mean = 74.38 Std. Dev. = 13.79 Sample Size = 34

TABLE 2

Results of Critical Thinking Test 1

Group	N	Mean	Standard Deviation	t	Alpha
Activity	36	73.08	12.34	-.42	0.68
Traditional	34	74.38	13.79		

FIGURE 5

Histogram of Scores on Attitude Survey
First Administration - Activity Group

```
5
-                             *                       * * *
-                             *         *         *   * * *
-                             *       * *   *   * *   * * *
-     *       *         * *   *   * * * * * * * * *   * * *
| - - - - | - - - - | - - - - | - - - - | - - - - | - - - - |
25        30        35        40        45        50        55
```

Mean = 46.53 Std. Dev. = 6.55 Sample Size = 36

FIGURE 6

Histogram of Scores on Attitude Survey
First Administration - Traditional Group

```
10
-
-
-
-                                       *
5                                       *
-                                       *     *     * *
-                                   *   *   * *     * *
-                                   *   * * * * * * * *
-                             *   * * * * * * * * * * *   *
| - - - - | - - - - | - - - - | - - - - | - - - - | - - - - |
25        30        35        40        45        50        55
```

Mean = 47.47 Std. Dev. = 3.45 Sample Size = 34

TABLE 3

Results of Attitude Survey

Group	N	Mean	Standard Deviation	t*	Alpha
Activity	36	46.53	6.55	-.76	0.78
Traditional	34	47.47	3.45		

* Separate Variance Estimate

Experiment II

Subjects

The subjects for this experiment were exactly the same 70 students who participated in Experiment I. However, in this investigation the experimental group assignments were reversed. The subjects who made up the traditional group in Experiment I were now assigned to the activity group. The subjects who made up the activity group in Experiment I, now were assigned to the traditional group.

Instrumentation

The content material and activities utilized in this investigation were taken from the chapter on "Acids and Bases" (Sund et al., 1980).

Content Learning. The test used to measure factual knowledge, hereafter referred to as "factual test 2" (Appendix E), followed the same format as factual test 1. However, it measured the learning from the chapter on "acids and bases." This test consists of 18 multiple choice and 7 completion items.

Critical Thinking. The test used to measure critical thinking, hereafter referred to as "critical thinking test 2" (Appendix F), followed the same format as critical thinking test 1. However, it measured the learning from the chapter on "acids and bases." This test consisted of 10 multiple choice and 4 essay items.

Attitude. The same attitude survey (See Appendix H) which was used in the first experiment was again utilized in this investigation.

Procedure

The same general procedures were followed in the second investigation as in the first, except that this time both groups studied Unit 3, Chapter 3, "Acids and Bases," in Sund's Accent on Science 6 (1980).

Upon the completion of the 8 sessions of treatment, taught according to the lesson plans included in Appendix B, both groups were given factual test 2 and critical thinking test 2 (Appendices E & F), respectively, over the topic of acids and bases. A compilation of the raw scores generated from these tests is included in Appendix L.

Directly following the administration of factual test 2 and critical thinking test 2 the attitude survey was again administered in the same manner as before. A compilation of the raw scores generated from this test is included in Appendix M.

Results

Content Learning. Figures 7 and 8 show the histograms and Table 4 shows the means and standard deviations of the activity and traditional groups on factual test 2.

Contrary to the first hypothesis, no significant difference was found.

Critical Thinking. Figures 9 and 10 show the histograms of the percentage scores and Table 5 contains the means and standard deviations of the activity and traditional groups on critical thinking test 2.

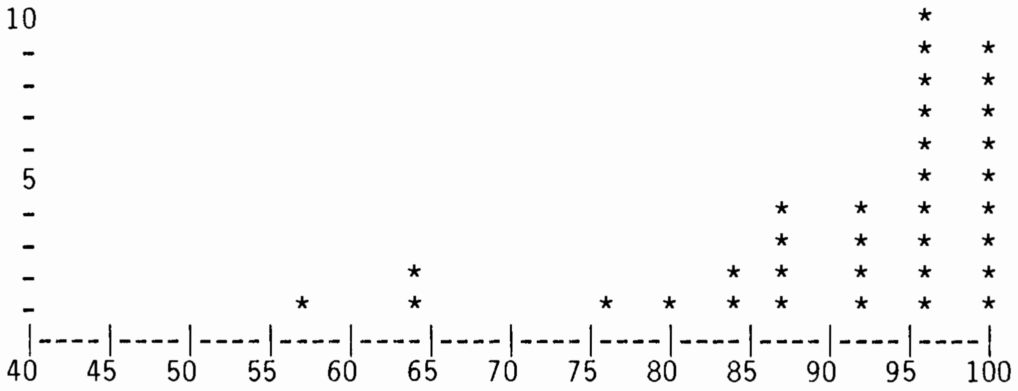
As in Experiment I, no significant difference was shown between the scores of the two groups. This finding does not support the first hypothesis.

Attitude. The histograms, Figures 11 and 12, and the means and standard deviations, Table 6, show the results of the attitude survey. In support of the second hypothesis, the mean of the activity group showed that these students were significantly ($p < .01$) more positive in their attitudes toward science than the students in the traditional group.

Coefficient alpha was again run on the attitude survey to ascertain its reliability. Coefficient Alpha = 0.90. Further information regarding reliability is included in Appendix J.

FIGURE 7

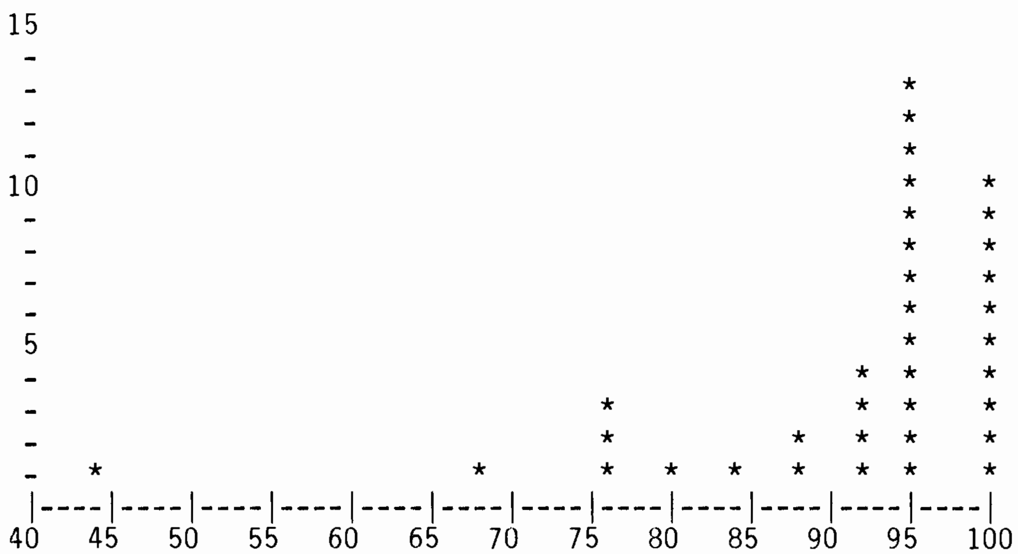
Histogram of Percentage Scores on Factual
Test 2 - Activity Group



Mean = 90.85 Std. Dev. = 11.11 Sample Size = 34

FIGURE 8

Histogram of Percentage Scores on Factual
Test 2 - Traditional Group



Mean = 91.55 Std. Dev. = 11.62 Sample Size = 36

TABLE 4

Results of Factual Test 2

Group	N	Mean	Standard Deviation	t	Alpha
Activity	34	90.85	11.11	-.25	0.79
Traditional	36	91.55	11.62		

FIGURE 9

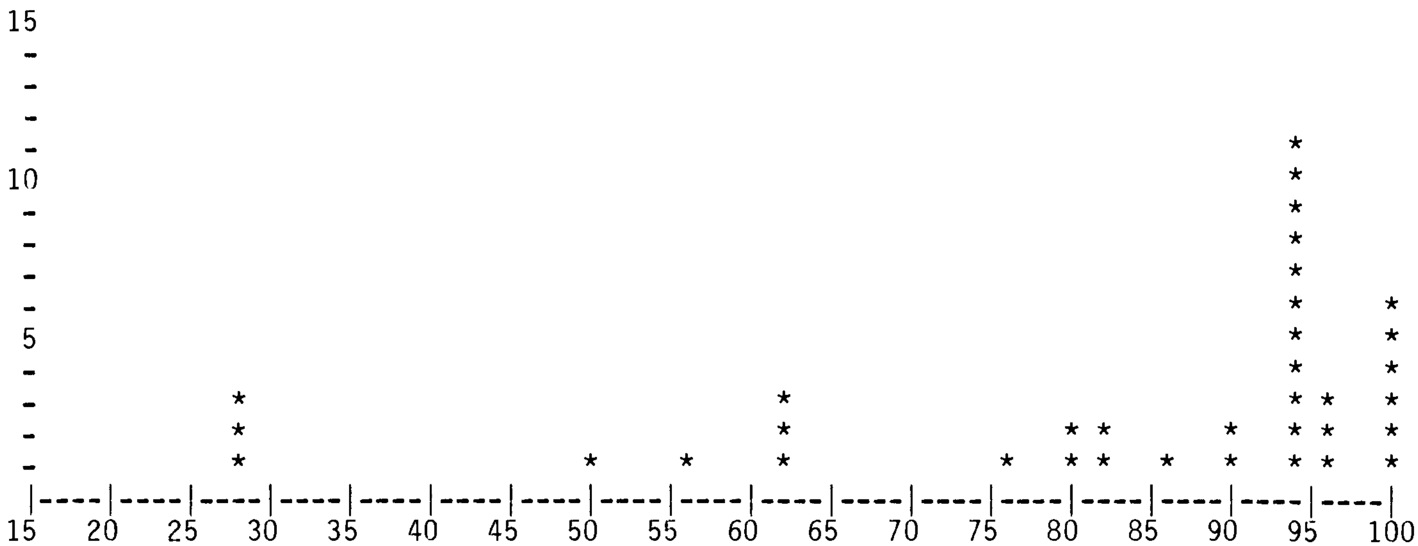
Histogram of Percentage Scores on Critical Thinking Test 2 - Activity Group

```
10
 -
 -                                                                                      *
 -                                                                                      *
 -                                                                                      *
 5                                                                  *                   *
 -                                                                  *     *             *
 -                *                                                 *     *       *     *
 -                *                                       *   *   * *     *       *     *
 -       *        *   *         *   *                     *   *   * *     *       * *   *
   |----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
  15   20   25   30   35   40   45   50   55   60   65   70   75   80   85   90   95   100
```

Mean = 77.03 Std. Dev. = 23.62 Sample Size = 34

FIGURE 10

Histogram of Percentage Scores on Critical Thinking Test 2 - Traditional Group



Mean = 81.92 Std. Dev. = 21.01 Sample Size = 36

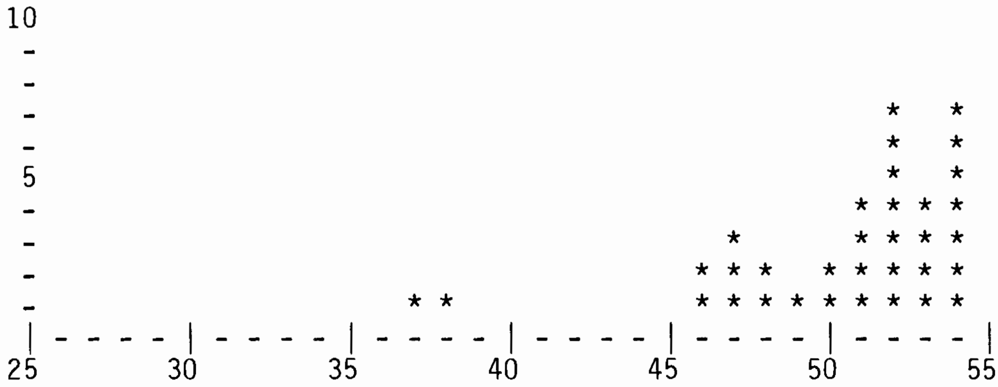
TABLE 5

Results of Critical Thinking Test 2

Group	N	Mean	Standard Deviation	t	Alpha
Activity	34	77.03	23.62	-.92	0.36
Traditional	36	81.92	21.01		

FIGURE 11

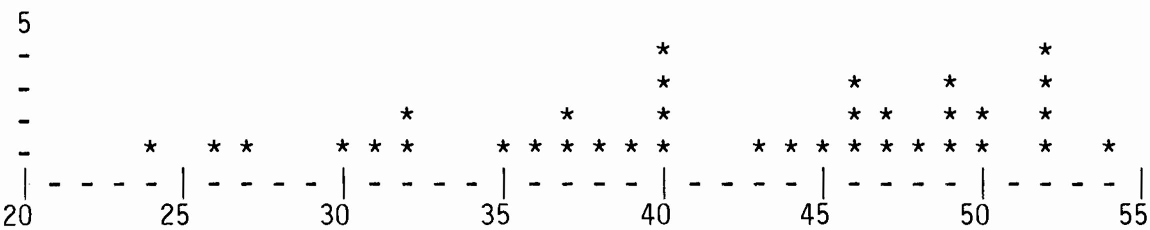
Histogram of Scores on Attitude Survey
Second Administration - Activity Group



Mean = 49.67 Std. Dev. = 5.09 Sample Size = 34

FIGURE 12

Histogram of Scores on Attitude Survey
Second Administration - Traditional Group



Mean = 42.00 Std. Dev. = 8.36 Sample Size = 36

TABLE 6

Results of Attitude Survey

Group	N	Mean	Standard Deviation	t*	Alpha
Activity	34	49.67	5.09	4.60	0.01
Traditional	36	42.00	8.36		

* Separate Variance Estimate

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

The purpose of this study was to compare the activity and the traditional approaches to teaching science. The effects of these two approaches upon sixth grade science content learning, critical thinking, and attitude toward science were the particular factors investigated here.

Content Learning

The results of this study did not support the first hypothesis, that the activity group would score better than the traditional group on tests of factual knowledge. In fact, the traditional group in Experiment I scored better in factual test 1 than the activity group, while no differences were found in factual test 2 given after Experiment II. However, the "ceiling effect" presents some difficulty in interpreting the "t" value. Another instrument should be used in further research which reduces the problem of "ceiling effect."

It is important to note that both groups scored an average of over 88 percent in these tests. Such high scores indicate that both the activity and the traditional groups acquired a good deal of factual knowledge contained in the chapters under study. In view of this observation, it is the researcher's opinion that either method is effective in teaching factual knowledge to students.

Whether or not the factual knowledge learned by students through the two opposing approaches under study here would be retained over time is a question that the researcher recommends for further study.

It is important to note here that the results of the present study do not help clarify the inconclusive, contradictory results of the literature (Bennet, 1965; Bredderman, 1982; Carpenter, 1963; Davis, 1976; Gerne, 1967; Marlins, 1973; Miller, 1967; Vanek & Montean, 1977; Voelker, 1975; Vongchusiri, 1974) reviewed in Chapter 4 as it related to student content learning. It is possible, as the researcher has stated, that one method is as effective as the other in teaching factual knowledge, and that the inconsistency of results is due to other variables, such as the teacher, the interest of the students in the content, and the amount of time given for classroom study. Further studies on how to use science curriculum and instructional strategies to enhance student content learning in elementary science are recommended.

Critical Thinking

The results of the comparisons of the measures of critical thinking did not support the first hypothesis, that the activity group would score better than the traditional group on the tests of critical thinking. No significant differences were shown between the activity group and the traditional group. These findings do not concur with research (Bredderman, 1982; Linn & Thier, 1975; Penick, 1976) reviewed in Chapter 4 in which activity taught students scored higher on tests of critical thinking than traditionally taught students.

Perhaps a major reason for this discrepancy between the present findings and the findings of other research involves the limited amount of time during which this investigation was conducted. While seventeen sessions were all the practical realities of the present study permitted, it seems obvious that this is not enough time to develop children's critical thinking.

The author suggests that research involving the development of critical thinking should be done over a much longer period of time and that, additionally, longitudinal studies be conducted into how critical thinking develops and how it can best be encouraged.

Another consideration here is whether or not the test itself actually measured critical thinking. Critical thinking tests 1 and 2 were utilized in the present study because they are included in the Sund (1980) curriculum and, therefore, are used regularly by classroom teachers. However, no reliability or validity figures for these tests are presented anywhere in the curriculum material. It is, therefore, difficult to know whether or not these tests actually measure critical thinking. Other studies of the development of critical thinking within students should include valid, reliable measures upon which to base findings.

A further reason why the findings of the present study did not agree with other research might be that the two groups contaminated one another by their presence in the same room at the same time. Though each of the two groups had specific activities which they were to complete during the treatment period, either of the groups could have been distracted by the activities of the other. Discussions and activities involving one group could easily have affected the other group in terms of their ability to perform on the tests not only of critical thinking, but also of attitude, and factual knowledge.

In addition, the textbook itself could have been a source of contamination in the sense that the group could have been affected by the very presence of the activity problems in it even though students did not investigate them.

Other studies using activity-oriented textbooks, as Sund's (1980) book was used in this investigation, should separate the two experimental groups entirely so that no chance for opposite-group contamination will occur.

Attitude

The attitude survey results did not confirm the second hypothesis in Experiment I. However, the results of the survey following the second experiment did support the hypothesis that the activity group would show more positive attitudes toward science than the students who received traditional instruction. Several reasons for this difference come to mind.

First, it is possible that subjects responded as they did during the second administration because they were affected by the first administration. Perhaps they answered as they did because they thought the administrator wanted them to respond in a certain way--they wanted the study to "succeed." Or, perhaps the subjects were confused regarding the directions during the first administration, but felt clear about what they were to do the second time.

It is also conceivable that subjects were more certain of whether or not they agreed or disagreed with the statements after the second 8-session treatment. They simply had had more time to formulate specific and certain attitudes.

In any case, because the survey itself was not very reliable, the author suggests that the data provided in Appendices I and J be used to help improve the reliability of the instrument. In addition, since the survey included several dimensions of science attitude, further use of the instrument might necessitate narrowing the questions to one type only so that a clearer reading of the results might be possible.

Recommendations for Further Research

In summary, the present study has generated the following recommendations for further research:

1. Studies of the long-range retention of factual knowledge acquired by elementary science students taught through activity and traditional approaches;

2. Another instrument should be used in further research which reduces the problem of "ceiling effect;"

3. Further studies on how to use science curriculum and instructional methods to enhance elementary science student content learning;

4. Longitudinal studies involving the development of critical thinking among elementary students;

5. The development and use of reliable and valid measures in studies of critical thinking;

6. Further studies comparing activity and traditional teaching methods within an activity-oriented, textbook-based, elementary program such as Sund's (1980) should take into consideration the problem of group contamination and take measures, such as separating groups by room, to control for it; and

7. The attitude survey (Appendix H) used in this investigation needs to be refined to show more reliability and validity if it is to be used in other research.

Final Comments

The researcher has reviewed and supplied a good deal of historical information regarding the theory and practices of science teaching as well as certain specific effects upon students taught through two teaching methods, activity and traditional. The following is a discussion of elementary science teaching, teachers, and learning which the author has derived from this information.

It is, first of all, important to note that historical circumstances affect the teaching of science in the elementary school. Moreover, with each newly perceived national problem has come a movement to reform science education so that somehow, that particular problem might be solved at some future time. The role of the learner, the methods used by the teacher, and the outcomes of teaching are all affected by each new reform movement. Today all educators will be grappling with a newly published report of recommendations to improve the schools (National Commission of Excellence in Education, 1983). The effects of this new impetus to reform on science education in the elementary school are yet to be seen.

Amid the cries for reform is the elementary classroom teacher. Throughout history it has been the teacher who has represented the major factor in determining whether or not learning actually occurs in the classroom and whether or not a reform movement succeeds or fails. It seems to the author that today's reform leaders will be no more successful at improving the learning of the nation's youth as reformers of the past have been, unless they consider carefully the classroom teacher.

A first consideration by reformers should be the state of the morale of classroom teachers. Today's elementary teacher considers the following "rewards" for dedicated service: relatively low salaries, relatively low public regard for the teaching profession, increased teaching responsibilities, increasing violence and turmoil in the classroom, and increased teacher layoffs, concurrent with the maintenance of large student-teacher ratios. Such "rewards" have not resulted in an eager, enthusiastic, patient population of classroom teachers. If "excellence in education" is an important national goal and one which can be expected to be attained, then a solid financial commitment from state and federal government to increase teacher salaries, hire more teachers and teacher support personnel, and thus decrease the student-teacher ratio in the schools is needed. In addition, the society at large must commit itself to the importance of an educated populace by supporting state and federal budget increases for education, by supporting teachers in the classroom, and by encouraging the importance of learning at home.

The preparation of elementary science teachers should also be considered by reformers. As noted in Chapter 2 the vast majority of elementary teachers lack scientific background. A greater emphasis upon the completion of science courses at the undergraduate level is needed. Every prospective elementary teacher should be required to take more courses in the sciences. Instead of producing elementary teachers who possess a "hazy" familiarity with some science generalizations, teacher educators must produce elementary teachers who have a thorough knowledge of the discipline. Dewey regarded knowledge of science discipline as a prerequisite for a good elementary teacher (Chapter 2). How else can one recognize opportunities for elementary science learning if one does not know the discipline of science itself?

Another closely related consideration is the education of practicing elementary teachers. Frequently, school districts offer barrier requirement credit for university courses taken in the educational area in which the teacher is assigned. University science courses in physics, chemistry, earth science, etc., are frequently not considered "within the educational area" of elementary teachers. Thus, important knowledge of the sciences which, it is believed by the author and Dewey, is needed in order to teach science to young children, is not acquired. If knowledgeable practicing elementary teachers are more effective in the classroom, as the author has suggested, school districts must commit themselves to encourage practicing elementary teachers to get back to the university and enroll in science courses.

In addition, it is important to add, the most knowledgeable scientist would not necessarily be a good elementary science teacher, for without an understanding of children and how they learn, teaching cannot proceed. Prospective teachers and practicing teachers must be given the opportunity in both their undergraduate and graduate education to study the theories of learning which have spurred the evolution of the two teaching methods investigated in this paper. Also, funds to encourage research by classroom teachers into how children learn would further strengthen the teachers' understanding of how to teach children best.

An important by-product of a knowledgeable elementary science teacher is the increased likelihood of that teacher arousing student interest in science. It seems clear to the author, on the basis of her own experience as a learner, an elementary teacher, and her reading of Dewey, that interest inspires learning and a desire to go on learning. According to the 1983 report by the National Commission of Excellence in Education, an identified nationwide need is a commitment to lifelong learning. Unless an interest in science is acquired by students during their elementary years it seems unlikely that a lifelong desire to pursue the discipline will result (Brandwein, 1951; Moore, 1962; Perrodin, 1966; Zim, 1941). Students are far more likely to develop an interest in science if taught by someone who is also interested--and knowledgeable enough to know which opportunities to tap--in science.

It is the author's opinion that, though the method and curriculum used by the teacher in the classroom are important variables to consider if reform is needed, it is the teacher who is the most important factor in whether or not children actually learn. Teachers who are limited in their knowledegе of science, to the point of being "curriculum-bound," provide fewer interest-building, learning opportunities for students. In order for real improvement in children's science learning to be realized, the teacher must possess (1) thorough knowledge of the discipline of science,

(2) thorough understanding of the theories of children's cognitive development and how children learn, and (3) the full support, both financial and moral of the society at large.

Recommendations for Further Research

1. Studies to determine the effect upon student learning of elementary teachers who possess a strong science background are recommended.

2. Studies to determine the effect upon student learning of elementary teachers who possess a strong theoretical background in how children learn need to be done.

3. Studies on science teaching and on learning, conducted by elementary teachers, or including elementary teachers as research associates, should be undertaken.

The author has chosen to combine historical information with a formal study which investigates the two major approaches to science teaching in the belief that science educators must be aware of the philosophy and history of science teaching, be acquainted with the societal forces which result in changes in teaching theory and practice, and then utilize that knowledge for the advancement of the teaching of science. It is thought that the present investigation supports that belief.

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APPENDIX A

Unit 3, Chapter 2, "Matter and Mixtures" Lesson Plans

Lesson 1

1. Introduce chapter to all students by using "Teaching Tip" 1 and "Text Questions," p. 94, from the Teacher Manual. In addition, use the "Supplemental Questions" on the same page.

2. Read over together paragraph 1, p. 95, and discuss "Supplemental Questions," p. 95.

3. Use class time for students to read "Mixtures," pp. 95-97. Use "Text Questions," pp. 95-96, discuss "Science Background," p. 96, and "Teaching Tips" 1-2, p. 96.

Lesson 2

Activity Group:

Use class time to perform the first "Teaching Tip," p. 95. Use small groups of 2 or 3 students. Ask students to record their observations by answering the 3 questions in the "Teaching Tip" (be sure they understand the meaning of "properties"). Discuss the activity.

Traditional Group:

Copy the boldface words and supply a definition in writing to be kept on a permanent (for this chapter) "Vocabulary Sheet." In addition, students should design 5 questions which can be answered by reading this selection ("Mixtures"). These questions will be used as a quiz next class period.

Lesson 3

Activity Group:

1. Do first "Teaching Tip," p. 97. Use small groups of 2 or 3 students per group. Materials: beaker of water, sugar cube, and stirring instrument.

2. Do first "Teaching Tip," p. 99. Materials: beaker of water, potting soil, and stirring instrument.

3. Discuss the differences between these two kinds of mixtures and assign students pp. 97-99, "Mixtures," to be read. Upon completion of reading, require students to name which mixture is the "solution" and which mixture is the "suspension."

Traditional Group:

1. While the Activity Group is being met with, this group should exchange their quizzes and take a neighbor's 5-point quiz. Upon completion, quizzes should be exchanged back for checking. Quizzes should be kept as a study help.

2. While the Activity Group is reading, discuss questions and quizzes briefly.

3. Assign pp. 97-99. Students will continue their vocabulary list as before and write out answers to "Text Questions," pp. 97-99.

Lesson 4

Activity Group:

Perform "Activity," p. 98, in small groups of 2 or 3 students each, as directed. In addition to the materials indicated, provide water of different temperatures, i.e., hot, room temperature, and cold. Discuss experiment.

Traditional Group:

Make a crossword puzzle using the vocabulary words. This puzzle will be exchanged with a partner and worked during class. Any additional time will be used for re-reading text material and completing "Text Questions," pp. 97-99.

Use final 10 minutes to discuss "Text Questions," pp. 97-99, with large group.

Lesson 5

1. Introduce p. 99 with "Teaching Tip" 3, p. 99.

2. Assign reading pp. 99-100 in class.

3. Discuss "Text Questions" on those pages. Refer to "Teaching Tips" 2-3 in discussion, p. 100.

Lesson 6

Activity Group:

Perform "Activity" during class time as directed and discuss. Use small groups of 2 or 3 students each.

Traditional Group:

Assignment--write a question which can be answered by each of the 6 "Summary Statements," p. 103. Answer them. Write out the answers to the questions on p. 103.

Lesson 7

1. Read over and discuss p. 102 as prescribed by the last "Teaching Tip" and "Supplemental Question."

2. Discuss the "Summary," "Science Words," and "Questions."

Lesson 8

Administer Tests A and B. Researcher will correct all tests.

APPENDIX B

Unit 3, Chapter 3, "Acids and Bases" Lesson Plans

* REMEMBER--the Activity Group is now the Traditional Group!

Lesson 1

1. Introduce chapter as prescribed in "Teaching Tips" 1-3, p. 104.

2. Read paragraph 1, p. 105, together and discuss "Text Questions." Continue discussion using "Teaching Tips" 3-4, p. 105.

3. Assign pp. 105-106, "Acids," to be read in class. Discuss.

Lesson 2

1. Introduce by using "Teaching Tips" 2-5, p. 106.

2. Assign pp. 106-107 to be read in class.

3. Discuss using "Text Questions," p. 107.

Lesson 3

Activity Group:

Assign "Activity," pp. 108-109, to be completed in class. The activity should be completed by small groups, 2 or 3 students per group, and discussed as manual suggests (See "Teaching Tips" 1-4).

Traditional Group:

Copy the boldface words from pp. 105-107 and supply a definition in writing to be kept on a permanent (for this chapter) "Vocabulary Sheet." In addition, students should design 10 questions which can be answered by reading pp. 105-107. These questions will be used as a quiz next class period.

Lesson 4

Activity Group:

Perform "Activity," pp. 109-110, in 2 or 3 student small groups, as directed in "Teaching Tips" 2-3, p. 110. Discuss.

Traditional Group:

While the Activity Group is experimenting, this group should exchange their quizzes and take a neighbor's 10 point quiz. Upon completion, quizzes should be exchanged back for checking. Quizzes should be scored and kept as study aid.

Lesson 5

Activity Group:

Complete "Activity," p. 111, in 2 or 3 student small groups. Perform and discuss as suggested, p. 111.

Traditional Group:

Make a crossword puzzle using the accumulated vocabulary words. This puzzle will be exchanged with a partner and worked during class. Any additional time will be used for re-reading text material.

Lesson 6

Introduce by using "Teaching Tips" 1, 4, and 5. Assign reading, pp. 112-113. Discuss using "Text Questions," pp. 112-113, and "Supplemental Questions," p. 112.

Lesson 7

Activity Group:

Perform "Activity," pp. 113-114, as directed, using 2 or 3 student small groups. Discuss.

Traditional Group:

Assign this group to write a question which can be answered by each of the 9 "Summary Statements," p. 115. Answer them.

Write out the answers to the questions, p. 115.

Lesson 8

Discuss "Summary," "Science Words," and "Questions," p. 115. Use "Summary Activity" as described, p. 115.

Lesson 9

Administer Tests A and B. Researcher will correct all tests.

APPENDIX C

Name ______________________________ Date ______________

Unit 3 The Structure and Behavior of Matter

Chapter 2 Matter and Mixtures

Part A

Write the word solution, suspension, or alloy in each blank.

1. Steel is a(n) ________________ of iron and carbon.
2. Sugar dissolved in water is a(n) ________________.
3. A mixture of gold and copper is a(n) ________________.
4. Tea leaves and water are a(n) ________________.
5. A(n) ________________ is made when salt is mixed with water.
6. Muddy water is one type of ________________.

Think of six different mixtures. Draw a picture of each mixture. Name each mixture in the blanks below.

7. ________________ 8. ________________

9. ________________ 10. ________________

11. ________________ 12. ________________

Name ______________________________ Date ______________

Unscramble the following words. Use each word in a complete sentence.

13. upnsnesiso ________________

____

14. uxrsetmi ________________

____

15. nuoltsio ________________

____

16. lolya ________________

____

Put an X in front of each statement that is true. Rewrite each false statement to make it true.

17. ____ Alloys can be separated by dissolving one substance.

____

18. ____ Sand and water can be separated by evaporation.

____

19. ____ Stainless steel is an alloy.

____

20. ____ The parts of a mixture are not evenly mixed in a solution.

____

21. ____ The parts of a mixture are evenly mixed in a suspension.

____

22. ____ Mixtures are not chemically combined.

____

23. ____ Brass is an alloy because it is made when the metals copper and zinc are mixed together.

____

APPENDIX D

Name ______________________________ Date ______________

Unit 3 The Structure and Behavior of Matter

Chapter 2 Matter and Mixtures

Part B

Use complete sentences to answer each question.

1. How is a solution different from a suspension?

____

____

____

2. Why are alloys sometimes used instead of pure metals for tools and jewelry?

____

____

3. Both brass and seawater are mixtures. Why must two different methods be used to separate each mixture into its parts?

____

____

____

Draw or write the answer to each question. Use complete sentences.

4. How can you separate a solution of sugar water?

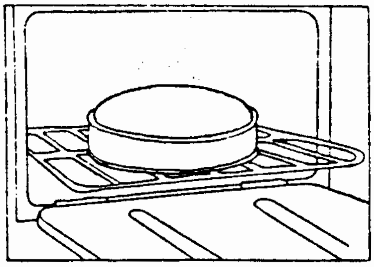
5. How can you separate a mixture of sediments in water?

Name ____________________ Date ____________

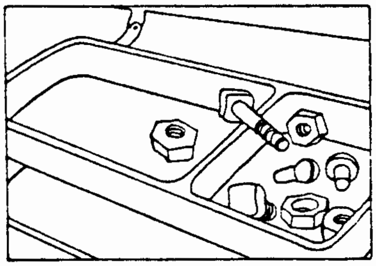
6. How can you separate iron filings from sand?

7. How can you separate salt from sand?

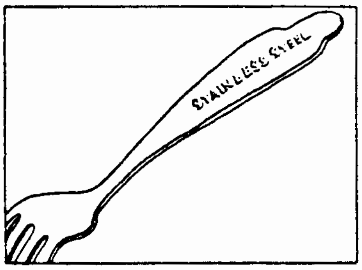
Tell whether each substance is a mixture or compound.



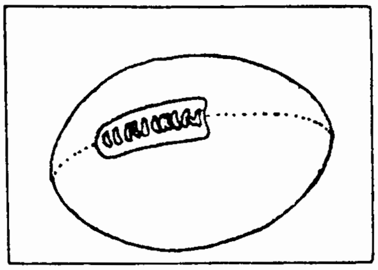
8. ____________________



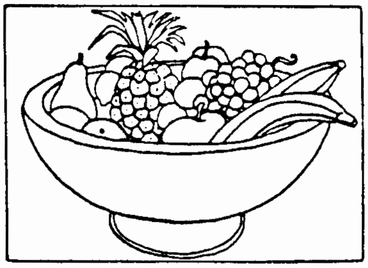
9. ____________________



10. ____________________



11. ____________________



12. ____________________

APPENDIX E

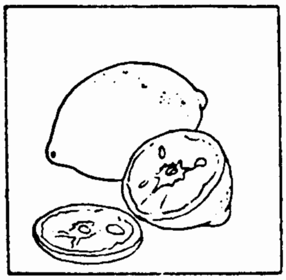
Name ________________________________ Date ______________

Unit 3 Structure and Behavior of Matter

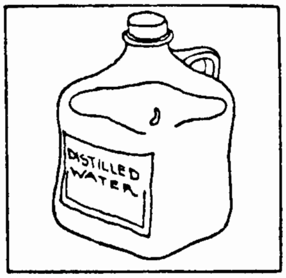
Chapter 3 Acids and Bases

Part A

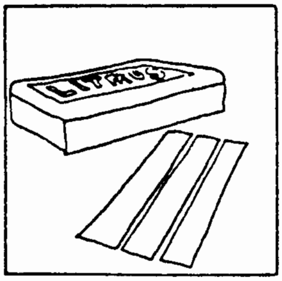
Look at the pictures. Tell whether each is an **acid, base, neutral** or **indicator** in the blank below each picture.



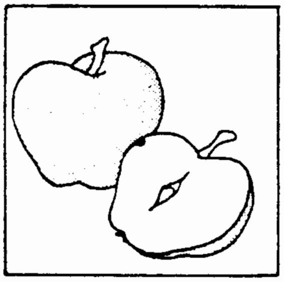
1. ____________________



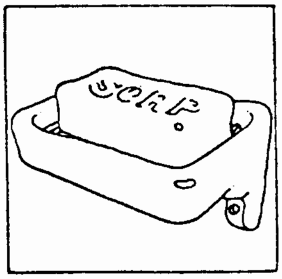
2. ____________________



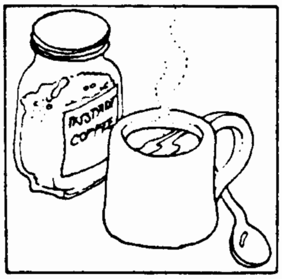
3. ____________________



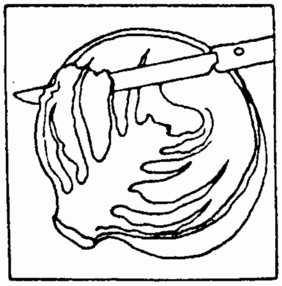
4. ____________________

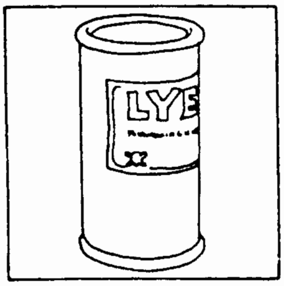


5. ____________________



6. ____________________





Name ______________________________ Date ______________

Fill in the blanks with the correct answers.

9. Acids cause the chemicals in __________________ to change from a blue to a red color.
10. Ammonia and lye are both chemical compounds called __________________.
11. Many acids taste __________________.
12. Bases feel __________________ when rubbed between the fingers.
13. A solution which is neither acid nor base is __________________.
14. Red cabbage and litmus paper are two kinds of __________________ used to test for acids and bases.
15. A new chemical compound is formed during a __________________.

Underline the correct word in the parenthesis.

16. Rusting is a chemical reaction which occurs (quickly, slowly).
17. A cold temperature (will, will not) affect the time it takes food to spoil.
18. Acids turn blue litmus paper (blue, red).
19. (Tea, Baking soda) is an acid.
20. Tasting an unknown substance is (dangerous, safe).
21. (Burning, Bending) is a chemical change.
22. (Acids, Bases) are used in automobile batteries.
23. A neutral solution (will, will not) affect litmus paper.
24. Baking soda causes litmus paper to change from (blue to red, red to blue).
25. (Strong, Weak) acids will cause burns.

APPENDIX F

Name ______________________________ Date ______________

Unit 3 Structure and Behavior of Matter

Chapter 3 Acids and Bases

Part B

Complete the chart. Which of these solutions are acids, bases, or neutral? Put a check (✓) under the correct column. Tell how each solution reacts with litmus paper. Write Red to Blue, no change, or Blue to Red, under the Litmus column.

Name of Solution	Acid	Base	Neutral	Litmus
1. lye				
2. distilled water				
3. vinegar				
4. ammonia				
5. coffee				
6. soap				
7. baking soda				
8. grapefruit juice				
9. lemonade				
10. tea				

Use complete sentences to answer each question.

11. What should you do if you spill acid on your hand?

____

____

12. What happens if you mix an acid with a base?

____

13. Give an example of a fast chemical reaction and a slow chemical reaction.

____

14. How does temperature change the rate of many chemical reactions?

____

APPENDIX G

Scoring Key

Factual Tests 1 and 2

Each of the items on these tests was assigned one point value. No half-points were given for "partially correct" items. In addition, spelling, and other mechanical errors were not counted as errors on the tests. The raw scores were then converted to percentage scores by dividing the number of correct items by the total number of items.

Critical Thinking Tests 1 and 2

Each of the items on these tests was assigned one point value. Half-points were given for partially, though not complete, answers. As in factual tests 1 and 2, writing mechanics were not counted as errors. The raw score was then converted to a percentage score.

The following answer keys were used to score all four tests.

Name ______________________ Date ______________

Unit 3 The Structure and Behavior of Matter

Chapter 2 Matter and Mixtures

Part A

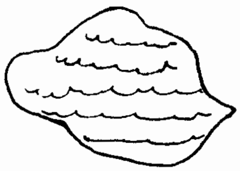
Write the word **solution, suspension, or alloy** in each blank.

1. Steel is a(n) ___alloy___ of iron and carbon.
2. Sugar dissolved in water is a(n) ___solution___.
3. A mixture of gold and copper is a(n) ___alloy___.
4. Tea leaves and water are a(n) ___suspension___.
5. A(n) ___solution___ is made when salt is mixed with water.
6. Muddy water is one type of ___suspension___.

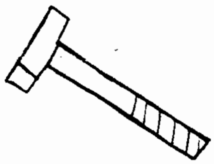
Think of six different mixtures. Draw a picture of each mixture. Name each mixture in the blanks below.

Pictures and answers will vary.

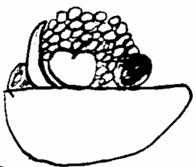
EXAMPLES:



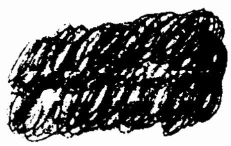
7. Seawater



8. Steel



9. bowl of fruit



10. soil

11. Some salad

12. lemonade

Name ______________________ Date ____________

Unscramble the following words. Use each word in a complete sentence.

13. upnsnesiso suspension
Wood chips in water form a suspension because they do not dissolve.

14. uxrsetmi mixtures
Two or more substances which make up a mixture can be easily separated.

15. nuoltsio solution
All the parts of a solution are evenly mixed.

16. lolya alloy
An alloy is a mixture of two or more metals.

Put an X in front of each statement that is true. Rewrite each false statement to make it true.

17. ____ Alloys can be separated by dissolving one substance.
Alloys cannot be separated by dissolving one substance.
or Alloys can be separated by melting the metals.

18. X Sand and water can be separated by evaporation.

19. X Stainless steel is an alloy.

20. ____ The parts of a mixture are not evenly mixed in a solution.
The parts of a mixture are not evenly mixed in a suspension.
or The parts of a mixture are evenly mixed in a solution.

21. ____ The parts of a mixture are evenly mixed in a suspension.
The parts of a mixture are evenly mixed in a solution.
or The parts of a mixture are not evenly mixed in a suspension.

22. X Mixtures are not chemically combined.

23. X Brass is an alloy because it is made when the metals copper and zinc are mixed together.

Name ______________________ Date ____________

Unit 3 The Structure and Behavior of Matter

Chapter 2 Matter and Mixtures

Part B

Use complete sentences to answer each question.

1. How is a solution different from a suspension?

   Solutions and suspensions are both mixtures; however, all of the parts are evenly mixed in a solution. In a suspension, the solid parts are not dissolved and mixed evenly in the liquid.

2. Why are alloys sometimes used instead of pure metals for tools and jewelry?

   Alloys may be stronger and harder than pure metals. Objects made from alloys may last longer and not scratch or rust as easily as pure metals.

3. Both brass and seawater are mixtures. Why must two different methods be used to separate each mixture into its parts?

   Brass is a solid alloy. Seawater is a liquid solution. Brass must be melted before the individual metals can be separated. Seawater can be separated by evaporating the water and gathering the solids which remain behind.

Draw or write the answer to each question. Use complete sentences.

4. How can you separate a solution of sugar water?

   Sugar water can be separated into its various parts by evaporation. The water evaporates. The sugar remains behind.

5. How can you separate a mixture of sediments in water?

   Sediments can be separated from water by either evaporation or filtering. The success of filtering may be determined by the size of the sediment particles and the size of the filter holes.

Name ______________________ Date ____________

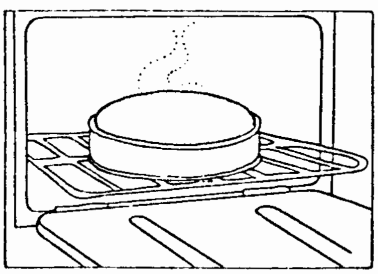
6. How can you separate iron filings from sand?

Iron filings can be separated from sand by using a magnet. The magnet will attract and collect the iron filings and leave the sand behind.

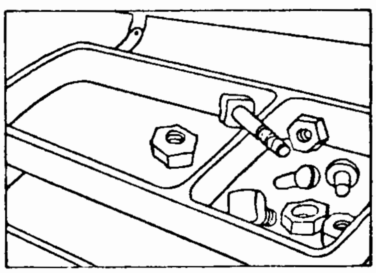
7. How can you separate salt from sand?

Salt can be separated from sand by first adding water to the mixture. The salt will dissolve in the water. The sand and saltwater are then run through a filter where the sand becomes trapped. The saltwater is then evaporated and the salt remains behind.

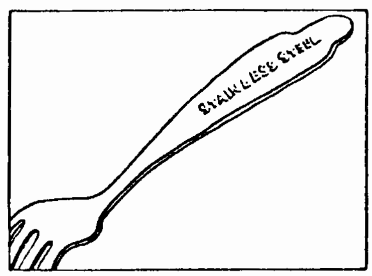
Tell whether each substance is a mixture or compound.



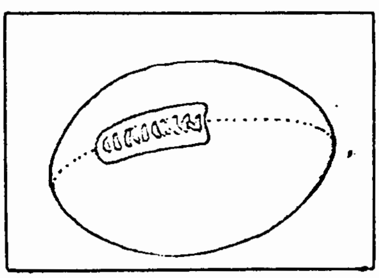
8. compound



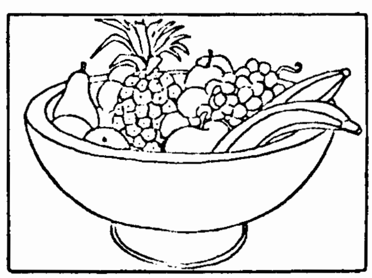
9. mixture



10. mixture



11. compound



12. mixture

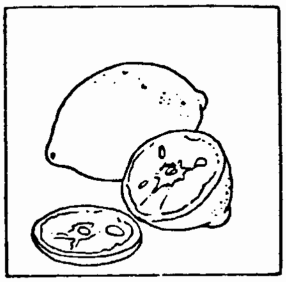
Name ______________________________ Date ______________

Unit 3 Structure and Behavior of Matter

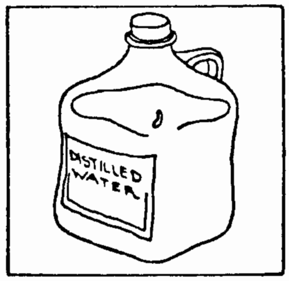
Chapter 3 Acids and Bases

Part A

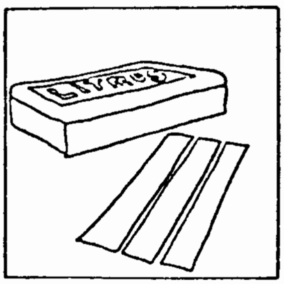
Look at the pictures. Tell whether each is an **acid, base, neutral** or **indicator** in the blank below each picture.



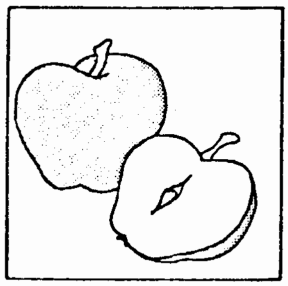
1. acid



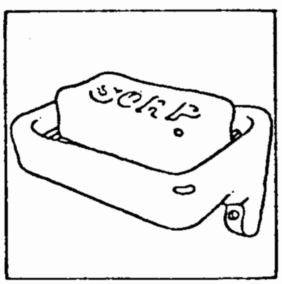
2. neutral



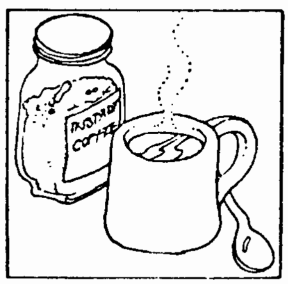
3. indicator



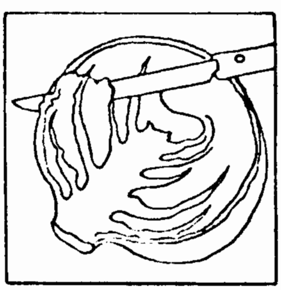
4. acid



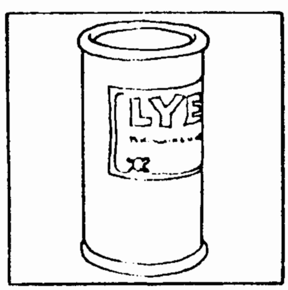
5. base



6. acid



7. indicator



8. base

Name ______________________________ Date ______________

Fill in the blanks with the correct answers.

9. Acids cause the chemicals in litmus paper to change from a blue to a red color.
10. Ammonia and lye are both chemical compounds called bases.
11. Many acids taste sour.
12. Bases feel slippery when rubbed between the fingers.
13. A solution which is neither acid nor base is neutral.
14. Red cabbage and litmus paper are two kinds of indicators used to test for acids and bases.
15. A new chemical compound is formed during a chemical change

Underline the correct word in the parenthesis.

16. Rusting is a chemical reaction which occurs (quickly, slowly).
17. A cold temperature (will, will not) affect the time it takes food to spoil.
18. Acids turn blue litmus paper (blue, red).
19. (Tea, Baking soda) is an acid.
20. Tasting an unknown substance is (dangerous, safe).
21. (Burning, Bending) is a chemical change.
22. (Acids, Bases) are used in automobile batteries.
23. A neutral solution (will, will not) affect litmus paper.
24. Baking soda causes litmus paper to change from (blue to red, red to blue).
25. (Strong, Weak) acids will cause burns.

Name ______________________ Date ____________

Unit 3 Structure and Behavior of Matter

Chapter 3 Acids and Bases

Part B

Complete the chart. Which of these solutions are acids, bases, or neutral? Put a check (✓) under the correct column. Tell how each solution reacts with litmus paper. Write **Red to Blue, no change, or Blue to Red,** under the Litmus column.

Name of Solution	Acid	Base	Neutral	Litmus
1. lye		✓		Red to Blue
2. distilled water			✓	No Change
3. vinegar	✓			Blue to Red
4. ammonia		✓		Red to Blue
5. coffee	✓			Blue to Red
6. soap		✓		Red to Blue
7. baking soda		✓		Red to Blue
8. grapefruit juice	✓			Blue to Red
9. lemonade	✓			Blue to Red
10. tea	✓			Blue to Red

Use complete sentences to answer each question.

11. What should you do if you spill acid on your hand?

The hand should be immediately rinsed with large amounts of water.

12. What happens if you mix an acid with a base?

A neutral mixture results from the combination of the correct amounts of an acid and base.

13. Give an example of a fast chemical reaction and a slow chemical reaction. Answers will vary. Burning is a fast chemical reaction. Rusting is a slow chemical reaction.

14. How does temperature change the rate of many chemical reactions?

An increasing temperature may speed up many chemical reactions. A decreasing temperature may slow down the reactions.

APPENDIX H

Attitude Survey

Directions

1. Instruct the students to prepare for this survey by explaining to them that it is an important part of the study. Even though some of the statements may seem odd to them, they are to consider each statement seriously and respond as they truly feel.

2. The survey will be given verbally. Students are to number a sheet of notebook paper from 1-18. In the upper right-hand corner they are to include their group letter (A designates Activity Group, T designates Traditional Group), and the current date.

3. Students are to understand that their names will not be used and that the results of this test will not affect their grades. In addition, students are to understand that there are no right or wrong answers so they should only be concerned about answering in the most honest way they can.

4. Students are to respond to each statement by placing "T," "0," or "F" beside the number on their paper. A "T" would indicate they they agree with the statement, "0" would indicate no opinion, and "F" would indicate they do not agree with the statement.

5. Students are to be given time to respond to the statements. No discussion is necessary concerning statements. Students are simply to respond.

Survey Statements

1. I look forward to science class.

2R. "I am not interested in [science]" (Remmers, 1960).

3. Science is an important subject for everyone to study in school.

4R. I have not learned much about (mixtures, acids and bases) during this unit.

5R. I wish I didn't have to study science in school.

6R. The activities I completed during this unit were boring.

7R. "[Science] is a waste of time" (Remmers, 1960).

8. I enjoyed the activities I was assigned to complete during this chapter in science.

9. It is always clear to me exactly what my assignment is during class.

10. I have learned quite a lot about (mixtures, acids and bases) during this unit.

11. "[Science] is a good subject" (Remmers, 1960).

12. I have learned a lot by completing the assigned activities.

13R. I dread science.

14R. "[Science] is a good subject only for the smart students" (Remmers, 1960).

15. Science is interesting to me.

16. I would like to study science as I have during this last chapter all the time.

17R. The directions I've received from my teacher telling me what I am to do during science are confusing to me.

18R. The activities I have completed during this chapter have not helped me learn.

APPENDIX I

Reliability Analysis For Attitude Survey

* Run Following First Administration

	Corrected Item-Total Correlation	Alpha, If Item Deleted
1	0.58	0.75
2R	0.62	0.75
3	0.32	0.77
4R	0.16	0.78
5R	0.52	0.76
6R	0.25	0.78
7R	0.44	0.77
8	0.33	0.77
9	0.23	0.78
10	0.23	0.78
11	0.55	0.76
12	0.27	0.78
13R	0.65	0.75
14R	0.30	0.77
15	0.56	0.75
16	0.18	0.79
17R	0.32	0.77
18R	0.21	0.78

Reliability Coefficients:

Number of Cases = 70.0 Number of Items = 18 Alpha = 0.78

APPENDIX J

Reliability Analysis For Attitude Survey

* Run Following Second Administration

	Corrected Item-Total Correlation	Alpha, If Item Deleted
1	0.80	0.89
2R	0.70	0.89
3	0.31	0.90
4R	0.51	0.90
5R	0.69	0.89
6R	0.64	0.90
7R	0.58	0.90
8	0.65	0.90
9	0.31	0.91
10	0.61	0.90
11	0.75	0.89
12	0.53	0.90
13R	0.73	0.89
14R	0.29	0.90
15	0.77	0.89
16	0.39	0.91
17R	0.24	0.91
18R	0.69	0.89

Reliability Coefficients:

Number of Cases = 70.0 Number of Items = 18 Alpha = 0.90

APPENDIX K

Group Matching Procedure

In order to equalize, as much as possible, the traditional and activity groups, the following procedures were used.

Within each of the three classrooms, data regarding sex, IQ (Kuhlemann-Anderson), and science subtest grade equivalent scores on the Iowa Tests of Basic Skills were gathered. Subjects within each class were then ordered, according to IQ score, with the highest IQ score at the top of the list, the lowest at the bottom.

The researcher then divided the class into two groups by placing the highest male IQ score in the first group and the next highest male IQ in the second group. The same procedure was followed using the female IQ scores; however, this time the highest female IQ score was assigned to the second group, the next highest female IQ score to the first group.

Science subtest grade equivalent scores were used as a third determining variable in dividing the groups when sex was equal and IQ scores were close to being equal among several subjects (i.e., four subjects with IQ's of 113 and ITBS science scores of 15, 54, 65, and 80 would be divided so that the ITBS science scores assigned to the first group would be 15 and 80 and to the second group 54 and 65).

APPENDIX L

Raw Data: Factual Tests 1 & 2 and Critical Thinking Tests 1 & 2

			--ACTIVITY GROUP--		-TRADITIONAL GROUP-	
Subjects IQ	ITBS Science Grade Equivalent	Sex*	Factual Test 1	Critical Thinking Test 1	Factual Test 2	Critical Thinking Test 2
1 : 141	97	1	100	88	100	100
2 : 134	108	1	100	83	96	93
3 : 134	55	2	96	75	96	93
4 : 130	101	2	91	83	100	93
5 : 129	81	2	96	71	96	96
6 : 121	**73**	1	87	71	100	96
7 : 113	65	2	70	50	80	29
8 : 113	72	1	100	88	96	96
9 : 112	47	1	96	63	96	93
10 : 108	37	2	48	50	88	82
11 : 104	58	1	87	63	92	61
12 : 103	55	2	100	75	92	89
13 : 119	**71**	2	100	92	100	100
14 : 143	97	2	91	92	100	93
15 : 141	104	1	78	75	100	93
16 : 136	90	2	100	75	100	93
17 : 129	90	2	100	83	96	100
18 : 129	72	1	96	79	96	93
19 : 126	53	2	96	75	92	93
20 : 126	97	1	100	79	100	86
21 : 124	72	2	83	75	100	79
22 : 114	63	2	78	63	96	100
23 : 113	33	1	91	71	84	82
24 : 108	81	1	78	83	76	57
25 : 99	58	2	65	58	68	50
26 : 146	60	2	89	75	96	100
27 : 135	90	2	96	79	96	93
28 : 134	90	1	96	92	96	93
29 : 131	41	2	87	58	76	61
30 : 128	72	2	91	79	96	61
31 : 123	101	2	96	79	96	100
32 : 123	72	1	87	67	100	89
33 : 117	97	1	91	79	76	75
34 : 113	37	1	61	46	88	29
35 : 109	50	2	96	67	92	79
36 : 86	37	2	52	50	44	29

* 1=Male 2=Female

Subjects IQ	ITBS Science Grade Equivalent	Sex*	-TRADITIONAL GROUP- Factual Test 1	Critical Thinking Test 1	--ACTIVITY GROUP-- Factual Test 2	Critical Thinking Test 2
37 : 145	104	1	100	79	100	93
38 : 132	86	2	91	75	100	93
39 : 128	72	2	100	71	96	100
40 : 123	65	2	100	96	100	86
41 : 117	60	1	100	75	96	79
42 : 113	22	1	96	42	76	82
43 : 113	86	1	91	79	100	93
44 : 110	101	1	100	75	96	86
45 : 106	58	2	100	83	100	79
46 : 120	97	2	100	96	100	100
47 : 105	76	1	87	54	96	79
48 : 101	58	2	74	67	92	86
49 : 137	114	1	96	92	100	100
50 : 132	90	2	91	79	92	71
51 : 128	86	2	91	79	100	96
52 : 122	72	1	70	79	92	32
53 : 120	76	2	100	83	96	100
54 : 116	55	2	87	54	96	100
55 : 131	111	2	87	67	96	100
56 : 113	93	1	96	79	100	100
57 : 112	63	2	91	54	57	36
58 : 106	72	1	91	83	88	75
59 : 102	60	1	96	92	96	75
60 : 134	93	1	100	88	88	86
61 : 131	93	2	96	83	84	71
62 : 129	93	1	96	50	80	82
63 : 129	60	2	96	75	84	32
64 : 123	58	2	96	79	96	32
65 : 123	72	2	91	63	88	100
66 : 118	58	2	96	88	64	46
67 : 112	33	2	87	54	64	50
68 : 112	22	1	91	58	88	21
69 : 111	97	1	96	83	96	79
70 : 113	47	1	100	75	92	79

* 1=Male 2=Female

APPENDIX M

Raw Data: Attitude Survey

Subjects	Experiment I Activity Group	Experiment II Traditional Group
1	54	46
2	46	49
3	44	47
4	40	46
5	43	31
6	49	52
7	52	49
8	53	50
9	54	52
10	54	48
11	54	32
12	52	47
13	50	44
14	38	39
15	32	40
16	48	50
17	50	26
18	49	24
19	40	27
20	44	30
21	53	37
22	45	36
23	53	38
24	52	40
25	53	46
26	40	43
27	40	52
28	47	45
29	47	32
30	45	37
31	28	40
32	42	52
33	37	49
34	50	54
35	45	40
36	52	35

Subjects	Experiment I Traditional Group	Experiment II Activity Group
37	47	38
38	51	53
39	51	52
40	45	51
41	46	53
42	46	48
43	43	53
44	48	53
45	48	54
46	47	54
47	48	54
48	48	54
49	45	37
50	43	51
51	52	47
52	51	47
53	50	52
54	52	52
55	49	52
56	54	46
57	45	49
58	45	52
59	45	51
60	44	48
61	43	50
62	52	52
63	52	54
64	50	52
65	51	50
66	42	51
67	40	54
68	47	46
69	45	54
70	49	47

APPENDIX N

Scoring Procedure: Attitude Survey

Student responses to the attitude survey statements were entered onto computer answer sheets in the following manner: Column A, disagree; Column B, no opinion; Column C, agree.

Each of the responses was then given a number value in the following manner: Disagree, 1; No Opinion, 2; Agree, 3. The computer then added each subject's responses generating a total score. The scores thus generated appear in Appendix M.