A STUDY OF THE USE OF FILMED VERSUS LIVE CLASSROOM OBSERVATIONS IN ARITHMETIC CONTENT-METHOD CLASSES AT WISCONSIN STATE UNIVERSITY-OSHKOSH

by

Harry L. Wolff
B.S., Wisconsin State University-Oshkosh, 1952; M.S., The University of Wisconsin, Madison, 1957

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Dissertation Committee:

Redacted Signature

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CHAPTER I

BACKGROUND OF THE PROBLEM

Introduction

The teacher-education movement, which has a history dating back to the seventeenth century, has not been noted for uniformity of programs or purposes over the years. The reasons for this apparent inconsistency are many and varied. In some instances, forceful men with compelling ideas have exerted extraordinary influence on the course of the movement. The introduction of a new theory of learning has frequently evoked a reaction, although sometimes belatedly, within the teacher-education community. At other times, fluctuating political, social, or religious climates have altered the aims and the practices of existing teacher-education programs. In addition, economics has frequently played an important role in fostering or discouraging innovations. All of these factors have tended to produce the lack of regularity characteristic of the evolution of teacher-education programs and purposes during the past three hundred years.

Although teacher-education programs have endured countless changes in aims and implementation during the last three centuries, there appears to have always been a strong belief that direct classroom experiences for pre-service teachers have considerable inherent value. Generally, the manifestation of this belief is evidenced by the regular occurrence of observation and student teaching in nearly all
teacher-education programs. In fact, the commencement of the teacher-education movement is usually associated with the appearance of the first schools of "practice" and observation.

The history of education reveals that the pioneer teacher educators of nearly three centuries ago held the observation of teaching and student teaching in high esteem. Historical accounts of the intervening years record a continuous stream of testimonials expressing the idea that both of these forms of experience should be included in any bona fide program of teacher education. Even today, nearly all teacher educators agree that these two activities play crucial roles in the preparation of teachers. In 1963 one of the authors of the Forty-Second Yearbook of the Association for Student Teaching expressed what appears to have been a common contemporary view. He said:

... Teacher educators, particularly those who have sought to improve teacher education through the extension of professional laboratory experiences, have always felt that real insight and understanding must come to the prospective teacher through observation and participation in the actual classroom where teaching is going on.1

There seems to be little doubt that this gentleman spoke for the Association, as well as to it, when he made this statement.

An investigation of the pertinent literature by a student of teacher education will, undoubtedly, make him aware of the significant values attributed to direct experiences for prospective teachers by modern teacher educators. Presumably, the reviewer will also recognize that arguments as to where, when, and how these experiences should be provided are commonplace.

The problem to be explored in this study is concerned with "where" and "how" the observation of teaching can be effectively employed in mathematics methods courses for prospective elementary school teachers. A consideration of "how" the observation of teaching should be accomplished leads very quickly to a confrontation with the often expressed "faith" in direct observation as a vital learning experience. The question of "where" the observation experience should be provided suggests the need for an examination of the types of facilities available for the observation of teaching. Together, these two questions direct the attention of the investigator to: (1) the function and utilization of observation, (2) the role of the campus school in providing observations, (3) trends in teacher education affecting observation, (4) recent developments in educational technology, and (5) to certain logistics problems in teacher education.

The focal point of this study, therefore, touches on many facets of the educative process just as the consideration of "where" and "how" the observation of teaching in pre-service teacher education can be realized necessarily requires the examination of several associated factors. The following paragraphs are designed to provide the reader with an overview of those factors which appear to have exerted the most direct influence on the problem of providing for the observation of teaching in the teacher-education programs of today.

The Belief in the Observation of Teaching

It has been asserted that teacher educators have always believed that the experience of observing teachers teaching has great value for pre-service teachers. The primary evidence to support this
contention is that the observation of teaching has been an integral part of nearly all teacher education programs since the inauguration of these kinds of instructional systems.

The educational historian, Ellwood P. Cubberley, has stated that: "The first normal school to be established anywhere was founded at Rhiems, in northern France, in 1685, by Abbe de la Salle."² The distinguishing feature of this particular school, which made it the first of its kind, was that schools of "practice" were provided for student teachers to observe model teaching and learn to teach under the direction and supervision of experienced teachers.

If La Salle's school is accepted as the beginning of the teacher-education movement, then it is a simple task for an investigator to trace the utilization of the observation of teaching through the teacher-education programs of the eighteenth, nineteenth, and twentieth centuries. Almost every major historical analysis of teacher education includes numerous references to the use of "observation and practice teaching" in the programs of the period. The reader may wish to consult Compayre³, Cubberley⁴, or Mead⁵ for typical accounts which describe the prominent role of the observation of teaching in early teacher-

⁴Cubberley. op. cit., pp. 745-783.
education programs. Walter S. Monroe\(^6\) provides an excellent description of the use of observation in teacher-education during the first half of the present century.

Further evidence can be found in the pronouncements of leading teacher educators whose experiences and positions have qualified them to speak authoritatively on the subject of teacher-education; from an analysis of the modern programs of teacher-education; from a study of the criteria set by teacher-education accreditation groups; and from some of the current research studies. All of these sources are rich in information which supports the assertion that teacher educators have always had a strong belief in the inherent value of the observation of teaching as a learning experience for prospective teachers.

This "faith" which teacher educators have in the educative powers of the observation of teaching serves in a substantial way to identify the problem to be considered in this study as one which should interest teacher educators generally. If the observation of teaching was a minor part of an insignificant number of teacher-education curricula, then a study concerned with "where" and "how" observations of teaching can be provided would most likely generate very little interest. However, since a widespread belief in the utility of these kinds of observations appears to exist within the teacher-education community, it seems reasonable to presume that a dissertation dealing with the implementation of observations of teaching has a high probability of engendering some degree of general concern.

This "faith" in the observation of teaching bears on the problem of this dissertation in a second way. The belief is usually expressed in terms of the direct observation of teaching. Thus, a statement of this belief tacitly assumes that the observations will be accomplished in regular functioning classrooms. Of course, until rather recently, there was little need to make the distinction between direct and indirect observations because teacher educators had no way of approximating what is ordinarily observed in the actual classroom. The alternatives were clear--either observations occurred in the classroom or there were no observations. Today, however, the distinction is significant because closed circuit television, video tapes, and motion picture films enable teacher educators to produce reasonable facsimiles of classroom situations. Whether or not one of these forms of indirect observation can be substituted for direct observation and still yield results which would not diminish the existing faith in observation is one of the aspects of the study.

Thus, the "faith" in the observation of teaching is relevant to this study for two reasons. First, the apparent universality of the belief indicates that the problem of this dissertation is of general interest. Second, since the key variable in this study is the substitution of vicarious for direct experiences, this study, in a sense, challenges the existing belief in direct observation.

**The Purposes and Objectives of Observation**

Throughout the history of teacher education, the primary purpose of the observation of teaching has been to orient the prospective teacher to the dynamics of the classroom. Until the rather recent
development of the so-called "participation" programs, the observation of teaching by the soon-to-be student teacher represented his initial contact as a student of teaching with the functioning classroom. The observational activity also represented the first of a series of steps designed to gradually induct the neophyte into the responsibilities of full-time teaching.

Since the general purpose of the observation of teaching seems to have been to enable the student to establish or confirm a concept of teaching-learning prior to the acceptance of some measure of responsibility for instruction, the concept of teaching-learning embodied in the teacher-preparation program of the institution served to identify the specific objectives of the observation. Thus, the immediate goals of the observation of teaching have tended to follow the twists and turns which have characterized the historical attempts to develop a concept of teaching or a teaching methodology.

It is beyond the scope of this commentary to assess all of the changes in the specific objectives of the observation of teaching which have occurred during the course of the teacher-education movement. There appear to be, however, three distinguishable eras in the teacher-education movement which are characterized by the distinctive approaches to teacher education employed at that time. These approaches to teacher education are identified with the prevailing concept of the teaching-learning process. Hence, the specific objectives of the observation of teaching tend to be categorized also.

Donald M. Sharpe described the rationale behind these three views of teacher education in 1956. He said:
The earlier programs of teacher preparation assumed that learning—teaching was a relatively simple process which could be learned by imitation. It assumed that there was a correct method of teaching, that the expert teacher could demonstrate this method, and that the student could adopt the method as his own. This approach emphasized the development of special skills and techniques. A later approach to teacher education assumed that one could become a teacher by learning the basic principles of teaching and applying them in future situations. This approach emphasized the study of abstract generalizations and theory.

Both approaches failed to recognize the dynamic complexity of the teaching-learning process. Both approaches failed to recognize that learning and doing are necessarily parts of a single act. One reason modern programs of teacher education differ from earlier programs is that they are based on different conception of learning. The modern conception of learning as problem solving has far-reaching implications for both the goals of teacher education and the methods of teacher education.

Modern teacher education in no way suggests that all one needs to do to understand children is to follow them around for six months. What it does insist upon is that in order to be able to work effectively with children the teacher must not only know what has been learned about their nature and behavior—that is, theory, but he must also be able to recognize the significance of those generalizations in the behavior of children and be able to take appropriate action.

The following remarks refer to the three periods mentioned in Sharpe's quotation, however, they have been re-labeled as the "early" approach, the "later" approach, and the "current" approach. The reader should keep in mind that it is highly improbable that any one concept of teaching has ever been able to describe all of the teacher-education activities existing at any given instant. Therefore, the comments to follow are an attempt to describe the prevalent practices during a given era.

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The Early Approach

The "early programs" of teacher education appear to be those existing in the United States and Europe prior to 1860 or 1870. The prevalent concept of teaching during this period, a holdover from the eighteenth century, viewed the teacher as a "school keeper" whose main instructional functions were to maintain discipline and to listen to recitations.

Pestalozzi's work during the first two decades of the nineteenth century appears to have had a significant influence on many of the European normal school programs by 1850—especially in Prussia and some of the other German states—but the ideas of Pestalozzi seem to have had little effect on American teacher education until after the Civil War. In 1843 Horace Mann was pressing to have normal schools in the United States adopt many of the forward-looking practices of their European counterparts. Even so, Sharpe referred to "Horace Mann's normal schools" and stated that in those schools the "'practice teaching' aimed primarily at transmitting to the prospective teacher the skills and techniques that the master teacher had acquired." Since "Horace Mann's" first normal school was established in 1839 and the normal school idea did not spread rapidly during the 1840's and 1850's, Sharpe's comment seems to indicate that he is speaking about the normal school programs prior to 1860 or 1870 or shortly thereafter.

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9 Sharpe, op. cit., p. 190.
The observation of teaching was an important part of the "practice school" experience offered by these early normal schools. The "young master" was usually required to observe the classroom technique of an "expert" teacher and then, when given an opportunity to do so, attempt to replicate that behavior under the critical eye of the "master." Generally, the focal point of the observation was the master teacher. Only rarely was the child in the classroom considered to be a proper subject for observation and analysis. Since the techniques employed by the expert teacher were assumed to be effective teaching agents, there appeared to be no need to ascertain the effect of the procedure on the child, or for that matter, on learning.

Success in practice teaching was measured, more often than not, in terms of the degree to which the student acquired and exhibited the behavioral pattern of the expert teacher. Thus, this period represents an era in which it was "assumed that learning-teaching was a relatively simple process which could be learned by imitation," and the specific objective of the observation of teaching was to identify those skills and techniques of the master teacher which the student was expected to acquire.

The Later Approach

The "later approach" to teacher education seems to describe the typical situation in a great many normal schools between 1870 and 1930. During this period of time, the teacher-education movement in the United States came under the influence of three major theories of learning. The first of these theories was associated with the Swiss educator

10Mead, op. cit., pp. 5-17.
Pestalozzi, the second with the German philosopher Herbart, and the third with the American psychologist Thorndike. Each of these men sought to develop an art or a science of teaching based on psychological principles of learning. Each met with varying degrees of success, and each, in his own way, left his imprint on contemporary education.

The beginning of teacher education as we know it today is usually identified with the life and works of Pestalozzi. One of the most explicit statements to this effect was made by Cubberley. He said:

... So long as the instruction in the vernacular school consisted chiefly of reading and the Catechism, and of hearing pupils recite what they had memorized, there was of course little need for any special training for the teacher. It was not until after Pestalozzi had done his work and made his contribution that there was anything worth mentioning to train teachers for. 11

An essential part of this contribution of Pestalozzi was his advocacy of the idea that an art or science of teaching based on a psychology of learning was obtainable. He expected to observe children closely, determine the manner in which they acquired knowledge, then develop a method of teaching which would capitalize on the natural way in which children learn. Compayre said:

He (Pestalozzi) wished, in fact, to simplify and determine methods (of teaching) to such a degree that they might be employed by the most ordinary teacher, and by the most ignorant father and mother. In a word, he hoped to organize a pedagogical machine so well set up that it could in a manner run alone. 12

With few exceptions, historians and biographers agree that Pestalozzi fell short of the goal he professed to seek. Nonetheless, he did focus attention on the role of the child in the teaching-

11 Cubberley, op. cit., p. 746.
12 Compayre. op. cit., p. 428.
learning process, because the method he sought was to be based on the learning capabilities of the child.

Pestalozzi used the observation of teaching unsparingly to instruct both student teachers and visitors attending his institutes.\(^\text{13}\) The focal point of these observations was the "method" or the teaching-learning activity. Since the learner played a prominent role in Pestalozzi's "object teaching" and "oral instruction," to focus on the "method" was to focus on the child. It would appear that Pestalozzi's contribution to the determination of the specific objectives of the observation of teaching was to include the activities of the learner as an object of observer interest.

The most significant feature of the last two decades of the nineteenth century was, however, the introduction and rapid rise to popularity of Herbartianism. Herbart, a contemporary of Pestalozzi, further defined Pestalozzi's concept of an art or science of teaching. Herbart's work proved to be more fruitful in that it resulted in a prescriptive method of teaching which is still popular, although in a slightly modified form, in some educational circles today.

The plan for teaching emanating from Herbart's work consisted of five steps: (1) preparation, (2) presentation, (3) association, (4) generalization, and (5) application. Each of these steps was capable of being described and illustrated by an expert teacher. Thus the observation of teaching tended to be aimed at comprehending the application of the method or the manner in which the teacher synthesized these five steps.

\(^{13}\) Ibid., pp. 434-435.
The main objective of the observation of teaching as it was utilized in teacher-education programs during this period appears to be to understand the principles of teaching as represented by the five-step method. The student teacher concentrated on the teacher's technique of motivating the students, of presenting the new ideas, of relating the new ideas to already established thoughts, of assisting the students in the identification of common elements in the new and old ideas which would lead to generalizations, and, finally, of suggesting applications of the newly acquired information.

Since the preparation was designed to arouse the interest of the learner, the presentation was to the learner, the association was to take place in the mind of the learner, the generalization was to be produced by the learner, and the new ideas were to be applied by the learner, it would seem that observations of this type of teaching would have directed attention to the student. In actual practice, unfortunately, the focal point of the observation was all too frequently the teacher and the plan, i.e., the method. In fact, Herbart was criticized for overemphasizing the role of the teacher. 14

Early in the twentieth century the teacher-education movement in the United States came under the influence of Edward Lee Thorndike. This man was essentially an experimental psychologist with a profound interest in educational psychology. Thorndike shifted the emphasis of teacher education from "How to teach?" to "How do we learn?"

Presumably, if this question could be answered satisfactorily, the first of the two questions would be resolved also.

Lawrence A. Cremin described Thorndike's search for a science of education. He said:

Ultimately, Thorndike's goal was a comprehensive science of pedagogy on which all education could be based. His faith in quantified methods was unbounded, and he was quoted ad nauseam [sic] to the effect that everything that exists exists in quantity and can be measured. Beginning with the notion that the methods of education can be vastly improved by science, he came slowly to the conviction that the aims, too, might well be scientifically determined. He deeply believed that with the training of a sufficient number of educational experts, many of the gnawing controversies that had plagued educators since the beginning of time would disappear.15

Some teacher educators have felt that Thorndike's influence affected teacher education negatively. Walter S. Monroe conducted a thorough analysis of the teacher education movement from 1890 to 1950. He concluded that between 1907 and 1933 (the period of Thorndike's greatest influence) the teacher-education movement temporarily lost its sense of direction and purpose. Monroe states: "The emphasis in the pedagogical-qualification area shifted from educational ideas to specifics; the desired teacher qualifications tended to be those of the technician."16 Bayles and Hood17 identified the same phenomenon and called it the "specific-objectivist movement."


16 Monroe. op. cit., p. 240.

The "specific-objectivist movement" was characterized by a research technique popularized by Thorndike as well as by a psychology of learning largely formulated by him. The research method as it was applied to curriculum construction consisted of a series of steps. First, the researcher studied the existing situation. (In terms of teacher education, this meant he observed teachers in the classroom.) Next, the researcher analyzed the existing situation to discern the human activities which make up the lives of men and women. (For teacher education, this meant an assessment and evaluation of the practicing teacher's activities.) Finally, the researcher ascertained the specific abilities and personal qualities necessary to perform the observed activities, and the development of those abilities became the educational objectives of the curriculum. 18

Monroe called this type of research the "studying of teachers as they are," and referred to the curriculum objectives derived by these methods as "specifics." 19

The psychology of learning formulated by Thorndike was the "stimulus-response bond" theory. During his lifetime, Thorndike used this theory to develop several "laws of learning," e.g., the law of exercise, the law of effect, the law of readiness, etc. Presumably, these laws described the manner in which learning took place and, together, they tended to dictate a method of teaching. Practically all teaching methodology emanating from a consideration of these "laws" and Thorndike's psychology characterized the teacher as a stimulus-

18Baylos and Hood. op. cit., pp. 196-199.
19Monroe. op. cit., p. 238.
provider and the learner as a reactor to very specific stimuli. Thus, the methods of teaching based on the stimulus-response bond psychology were necessarily of a rather mechanical nature. This fact, together with the notion that teacher-qualifications should be specific abilities, probably produced the teacher "technician" referred to by Monroe.

Since the observation of teaching was an essential part of nearly all teacher-education programs during this period of time, it too was subject to the influence of the "specific-objectivist movement." During the second and third decades of this century, complete courses dealing exclusively with the techniques of observation appeared with increasing frequency in teacher-education curricula. 20

Concurrently, numerous textbooks devoted entirely to observation and student teaching appeared on the market. 21 The content of these textbooks indicates that prospective teachers were expected to observe: the pupils in the class, the teacher, the ongoing activities, lighting, ventilation, heat, seating, blackboards, class routine, discipline, equipment, and almost everything else capable of being examined. After each observation, the student was required to complete a detailed check-list and write a report which described all he had witnessed.


In the preface of their textbook on observation and student teaching, a statement by Wrinkle and Armentrout suggests "that it is highly improbable that the average beginner will find it possible to observe teaching activity as a whole at the outset of his study." Therefore, they proposed to split teaching activity into its constituent parts and utilize observation to scrutinize each subdivision.

A perusal of Blackhurst's text reveals that he postponed consideration of the "instructional phase of the classroom activities" until after the student completed sixteen lessons dealing with "the setting in which educational procedure is to take place." Each of these lessons focused attention on a single aspect of the classroom setting.

The format of both of these books is the same. The intent is to partition observation into several specific subactivities, and then proceed to develop the student's ability to perform each of the supposedly less complicated tasks. This is precisely the "specific-objectivist" pattern of curriculum construction.

The influence of Thorndike on the aims of the observation of teaching seems to have been to fragment the objectives. The observer's attention was directed to details, details of method as well as details of the physical setting. Teaching was viewed as a series of stimulus-response situations, and learning was presumably described by the laws of exercise, effect, readiness, etc. It is interesting to note that

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22 Wrinkle and Armentrout. *op. cit.*, p. xi.

the observation reports of Wrinkle and Armentrout requested the observer to cite examples of "readiness," "effect," and "exercise."
Thus, the student was expected to recognize the application of Thorndike's "scientific laws of learning."

In different ways, Pestalozzi, Herbart, and Thorndike attempted to prescribe an art or science of teaching based on specific psychological principles. In a sense, they attempted to mechanize teaching. While each one put theoretical emphasis on the role of the learner by stressing the psychological aspect of learning, in practice, the teacher remained the dominant figure in the teaching-learning confrontation.

The observers of teaching continued to place primary emphasis on "what the teacher was doing." The specific objective of the observation of teaching under all of these theories was to comprehend the application of principles, laws, or generalizations to the instructional situation.

The Current Approach

After 1930, many teacher educators—especially members of the American Association of Teachers Colleges—sought to reorganize the goals for teacher education. During the next decade, the purposes of teacher education were re-defined to reflect the objectives of the public elementary and secondary schools. The synchronization of the purposes of teacher education and public education led to a very serious consideration of the purposes of education in a democracy.

The acknowledged leader of this movement to have democracy and democratic living considered as logical sources of educational objectives

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24 Wrinkle and Armentrout. op. cit., p. 223.
in the public schools was John Dewey. His influence, both personal and through students like William H. Kilpatrick, became more apparent after 1930 although he had been recognized as an outstanding educational philosopher since the turn of the century. During the first third of this century Dewey's work tended to be over-shadowed by that of Thorndike. 26

According to Monroe 27, the "new" objectives for teacher education emphasized understanding the purposes of education in a democracy, social involvement, a broad general education, technical competency in the classroom, an understanding of both the personality and intellectual development of children, and the development of "personal qualities that would contribute to desirable teacher-pupil relationships in classroom situations."

The trend toward greater social involvement by the teacher was accompanied by more insistent demands for increased opportunities for direct experiences in teacher-education programs. Where previously, the direct experience of the prospective teacher was chiefly confined to observations of teaching and student teaching, innovative programs of teacher education provided a wide variety of contacts between youngsters and future teachers. These activities were generally classified as "participation" and they were usually introduced early in the collegiate program of the student of teaching. With increasing frequency, the "participators" were required to observe and analyze the social and intellectual behavior of children, youth, and adults apart from the

27 Monroe, op. cit., p. 255.
teaching situation. These types of experiences appeared to modify the role of the observation of teaching.

The participation activities which occurred in the classroom also seemed to be designed as an intermediate step between the observation of teaching and student teaching. There are many who view these participation experiences as a unique opportunity for the prospective teacher to acquire many of the routine skills and mechanical techniques of the experienced teacher. Those who accept this view tend to relieve the observation of teaching of many of its traditional responsibilities and to emphasize new objectives for this age-old activity.

In 1904 Dewey identified a specific aim for the observation of teaching, an objective which directs much of the current observational activity. He recommended that the observation of teaching should be employed to mitigate "the danger of bringing the would-be teacher into an abrupt and dislocated contact with the psychology of the classroom."

Dewey suggested that the observation of teaching provided a unique opportunity for the prospective teacher to make a less traumatic psychological transition from student to teacher. He said:

The first observation of instruction given by model- or critic-teachers should not be too definitely practical to aim. The student should not be observing to find out how the good teacher does it, in order to accumulate a store of methods by which he also may teach successfully. He should rather observe with reference to seeing the interaction of mind, to see how teacher and pupils react upon each other -- how mind answers mind. Observation should at first be conducted from the psychological rather than from the 'practical' standpoint.

It would appear that this recommendation of Dewey's has been implemented in many modern teacher-education programs. Most forward-looking programs do provide for three general classes of direct experiences, i.e., observation, participation, and student teaching. Since 1930, there has been a trend to include the observation of teaching in psychology and social foundations courses. This would indicate that the objectives of observations in these classes are psychologically or sociologically oriented. In addition, much of the research involving observation during the past two decades has been concerned with the characteristics of teacher-learner interaction at the verbal level, at the affective level, and at the psychological level. Unlike the courses in observation of the 1920's which concentrated on the physical aspects of the classroom and the methods of teaching, the modern approach is to train the student to record more detail of observed social interaction, to be more objective, to acquire a sensitivity to nonverbal communication, and to discern patterns of behavior. One of the authors of the Forty-Second Yearbook of the Association for Student Teaching referring to the writings and research directed along these lines stated:

"Teaching is seen as interacting with learners rather than instructing

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them in the traditional sense." Thus, there seems to be considerable interest in investigating the psychological aspects of the teaching-learning situation and there is some evidence that one of the current specific objectives of the observation of teaching in many teacher-education programs is to orient the prospective teacher to the "psychology of the classroom."

The significance of the identification of the current view of the immediate objective of the observation of teaching for this study is that any experiment which substitutes vicarious experiences for direct experiences should consider the affective aspect of the observational activity. If there is agreement among teacher-educators that the observation of teaching does play a role in determining the observer's self concept, in affecting his attitude toward teaching-learning, and in developing confidence in his ability to teach, then these factors should be taken into consideration when the study is designed.

The Campus School

The "practice school" has served the needs of teacher education since before the time of Pestalozzi. Throughout the nineteenth and well into the twentieth century, these schools provided nearly all the direct experience teacher trainees received. The earliest of these schools, both in Europe and the United States, stressed observation, demonstration teaching, and student teaching, but many of them—especially the private schools headed by zealots and reformers—were centers of experimentation and innovation.

The history of the "practice school" reveals that it has had several different names over the years and that it has been linked to the teacher-education institution in a variety of ways. For purposes of clarification, the following remarks in this section pertain to the "campus laboratory school" which is "entirely under the control of the college, located on or near the college campus, organized for the specific purpose of preparing teachers, with staff and facilities designed to serve this purpose."\(^{32}\) This type of school has enjoyed great popularity in the past. At the present time, however, serious questions are being raised concerning its role, its function, its future, even its value.

As teacher training institutions in this country changed from normal schools to teachers colleges and eventually into state colleges and universities, the campus schools seemed to adapt to the new conditions and to continue to be important and useful facilities for the preparation of teachers. In recent years, the pressures for greater amounts of direct experience and for new instructional programs forced the campus schools to assume a host of new responsibilities. In addition to the traditional functions involving observation, demonstration teaching, and student teaching, the campus schools have attempted to provide "participation" experiences, research and experimentation facilities, special programs for prospective teachers of handicapped or retarded children, preparatory activities for internships, and leadership

\(^{32}\) Hollis J. Caswell. "The Place of the Campus Laboratory School in the Education of Teachers." Teachers College Record, 50 (April, 1949) 441.
for in-service programs. The inability of the campus school to perform all of these functions has created confusion as to what the role of the campus school should be.  

The doubtful status of the campus school is reflected in a number of articles which state "still another campus school has been closed and time is running out on the rest," and varied reports which assert that "although some laboratory schools have been closed recent surveys indicate that more are being planned or established than are being discontinued." Some individuals point to the fact that student teaching activities are being shifted to the public schools, thus the primary reason for maintaining a campus school will, in the near future, no longer exist. There are a few educators who will argue that the campus school is outdated and should be eliminated, but there are others who insist that the campus school is an essential part of any teacher-education program. The claim has been made by one writer who surveyed the opinions of over one hundred campus school directors that "there is close to universal agreement . . . as to what roles or functions the laboratory school may perform," but another investigator says "there is no apparent agreement among campus laboratory schools or

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35 Jackson, op. cit., p. 293.

sponsoring institutions as to the relative importance of the functions performed."\(^{37}\)

Some maintain that the laboratory school should stress the functions of observation and participation, while others insist that the future success of the campus school depends entirely upon the degree of emphasis it gives to research and experimentation. The one common conclusion most reviewers of the current literature on campus laboratory schools reach is that the campus laboratory schools are in a state of transition, and, at the moment, their future role in teacher education is unpredictable.

**Observation in the Campus School**

One function of the campus laboratory school, that of providing observations for prospective teachers, seems to have withstood the pressures of change and innovation more successfully than many of the other campus school activities. Whereas observation and student teaching once represented the primary functions of the laboratory school, student teaching is now being removed to the public schools. Even the acquisition of new functions by the campus school appears to have had less effect on observation than on some of the other related activities.

In 1949, one investigator surveyed laboratory schools in four southeastern states and concluded that observation and participation were the two main functions of these schools.\(^{38}\) Another study, in


1964, indicated that observation of teaching was the most important function of one hundred eighty-six laboratory schools investigated.\(^{39}\) Finally, Jackson\(^ {40}\) reviewed several studies dealing with the functions of campus laboratory schools and concluded that the authors of the studies he reviewed consistently ranked observation at or near the top of their "functions-performed list." The foregoing evidence seems to indicate that the observation of teaching is one of the more important laboratory school functions.

Yet, the future status of the observation of teaching as an important function of the laboratory school may not be as secure as the foregoing information might seem to indicate. The confused atmosphere surrounding the future roles of the campus laboratory school automatically raises questions concerning the future of observation. In fact, much of the confusion results from the competition among the various functions for positions of prominence in the activities of the campus school. The results of this infighting may well prove to be unfavorable to the observation of teaching.

At least one author has argued that observation should be given a low priority because "to rank it most important would seem to overlook the fact that participation, student teaching, research, and experimentation involve more active participation on the part of the student and are more directly related to the actual process of teaching."\(^ {41}\) Yet,

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\(^{40}\) Jackson. *op. cit.*, pp. 293-303.

\(^{41}\) Jackson. *op. cit.*, p. 301.
another study has indicated there are four times as many campus school directors who expect research and experimentation to receive increased emphasis in the future than there are directors who expect observation to receive similar attention. While some of these directors expect a decrease in the amount of observation conducted in their laboratory schools, none of them expect research and experimentation to be de-emphasized. 42

Other investigations have indicated that research and experimentation which require contrived and controlled situations tend to be incompatible with most all of the other laboratory school functions. Thus, it would appear that the future status of the observation of teaching in the laboratory school may be something considerably less than it is today.

The uncertainty surrounding the present and future roles of the typical campus laboratory school bears directly on the problem of this dissertation because the specific problem investigated was created in part by conditions quite similar to those described above. The campus laboratory school of the institution at which the experiment was conducted has been subjected to most of the contemporary pressures to update its offerings and to re-evaluate its role in the existing program of teacher education. In particular, the observation of teaching has been de-emphasized and alternative methods of "observing" are being sought. Particularly, if in the past an institution has relied almost

42 The Association for Student Teaching. New Developments, Research, and Experimentation in Professional Laboratory Experiences, Bulletin Number 22. The Association for Student Teaching, Cedar Falls, Iowa, 1964, pp. 141-144.
entirely on a campus laboratory school to provide for the observation of teaching, as this institution has, then in view of the information presented in this section, it would seem that the consideration of "where" and "how" the observation of teaching can be conducted is both a crucial and a general problem.

The Research Trend

One of the phenomena which bears directly on the problem of this dissertation is the trend toward increased research activity in teacher education, particularly in the area of professional laboratory experiences. It was pointed out in the last section that a substantial increase in the research and experimentation function of the laboratory school would constitute a threat to the continuation of the preferential treatment that observation of teaching has received in the past, since there are indications that the two types of activities tend to be mutually exclusive. Some information concerning this trend was provided in the last section. The following paragraphs may provide additional evidence to substantiate the assertion that a trend toward increased research activity in the campus laboratory schools is underway.

The alleged trend toward increased research is a relatively recent development. In 1962, Alberta Lowe \(^4^3\) presented a paper on the "Implications of AST Research" to the Association for Student Teaching. In her paper she identified four milestones in the teacher-education research movement. The interesting point to note is that the earliest

of these momentous events was dated 1957. It seems significant that the first major event in teacher-education research conducted by the Association occurred just five years prior to the date of the speech.

Other reputable research authorities agree generally with Lowe's designations. Speaking in 1965, Ralph W. Tyler discussed the twentieth century educational research movement saying: "In summary, the field of educational research has greatly developed in the past forty years, and most rapidly during the past decade." Another researcher who participated in this same symposium said: "The past decade has seen a remarkable burgeoning of educational (research) activity."45

A 1967 publication of the Association for Student Teaching which concerned recent research in teacher education contained an introductory summary of the contents by Henry J. Hermanowicz. In his opening statement Hermanowicz said: "The 1960's and perhaps the 1970's in the history of American teacher education probably will be remembered as decades triggering intensified examination, criticism, and experimentation."46 Thus, it appears that several prominent researchers recognize the recency and the intensity of the trend in educational research.


Those assertions by authorities in the field of educational research can be supported by other forms of evidence. In a study reported in 1964, Blackmon surveyed "125 NCATE-approved institutions having college-controlled laboratory schools concerned with research." He found that the research function was being given a greater priority than it had been previously awarded. He said: "Research and experimentation are receiving more emphasis, with a slight trend toward becoming a co-equal or primary function in the schools studied." In addition, he concluded that there was a "consensus" among campus school administrators that there "should be an enhancement of the research function" of the laboratory schools. 47

Blackmon's study was concerned directly with laboratory schools and is representative of the tendency for professional laboratory experiences to be the focus of an inordinate amount of teacher education research. Further evidence of this tendency can be obtained from a study of the literature, i.e., surveys of appropriate periodicals reveal that the results of studies involving professional laboratory experiences are reported more frequently than are studies concerned with the other facets of teacher education. For example, a perusal of the 1966-1968 issues of "The Journal of Teacher Education" shows that nearly half of the fifty-six research experiments and surveys reported dealt directly with student teaching and other laboratory experiences.

The "Journal of Teacher Education" also presents annual listings of doctoral dissertations in the area of teacher education. Of the eleven categories of problems considered by the dissertations, one is headed: Student Teaching and Other Preparatory Experiences: Laboratory, Field, Direct. In 1958, there were fourteen studies listed in this category. This represented about ten per cent of the total number of studies. After 1958 there is a pronounced trend toward increased activity in this area. The most recent listing includes sixty entries in this category--more than twenty-five per cent of the total number of dissertations. Also, it may be noted, the sixty studies are twice the number of dissertations in any other category.

The pronouncements of experts, the results of specific studies, the frequency of reported research, and the listings of doctoral dissertations all seem to indicate that: (1) a trend toward increased research activity in teacher education exists; (2) the trend is a recent development; and (3) the greatest activity seems to be in the area of professional laboratory experiences. Thus, the threat to the future status of the observation of teaching in the laboratory school is probably a real one.

The Increased Enrollments

There is no question that higher education has experienced fantastic yearly increases in enrollments during the past decade. The magnitude and rate of these increased enrollments have created a variety of problems for the host institutions. The problems begin with frantic efforts to get the "multitudes" registered in a reasonable length of time and end with the nearly hopeless task of locating possible indoor
facilities for graduating exercises "in the event of inclement weather."
In between these two events, almost every conceivable administrative
and instructional function of the school is affected in some way,
usually adversely, by the ubiquitousness of the students.

The number of students enrolling in teacher education reflects
the phenomenal general growth of the student population. Although it
appears that all phases of the teacher-education programs have been
affected by these very unusual enrollments, the problems involved with
the provision of appropriate professional laboratory experiences for
teacher-education students seem to be especially acute. In particular,
the programs of the college-controlled laboratory schools have suffered
under the burdens imposed by attempts to accommodate from three to ten
times the number of students for which the campus schools were origi-
nally designed.

In 1958, the authors of "The Purposes, Functions, and Unique-
ness of the College-Controlled Laboratory School" listed four "critical"
problems affecting the role of these schools. They were: (1) the
expanding demands on the laboratory school, (2) rising costs, (3)
increased pressure on personnel in the laboratory school, and (4) the
integration of professional laboratory experiences with the total
college program. The authors strongly implied that each of these prob-
lems was aggravated, or possibly caused, by the increased number of
teacher-education students. Yet, it should be noted that the
enrollment boom had hardly begun in 1958.

48 The Association for Student Teaching. The Purposes, Functions,
and Uniqueness of the College-Controlled Laboratory School, Bulletin
Number 9. The Association for Student Teaching, Cedar Falls, Iowa, 1958,
pp. 9-20.
There have been various attempts to solve some of the problems facing the laboratory schools. Teacher educators, encouraged by the results of shifting student teaching to the public schools, have tried to do the same with the observation of teaching, but with little success. Goodlad pointed out that "The sheer logistics of arranging for meaningful observations in schools and classrooms are formidable." 49 Woodward was much more specific. He said:

One phase of teacher training, that of classroom observation, has become burdensome to the institution, the public schools, and to the teacher-training students. It is difficult for the college or university to locate and supervise properly enough suitable observations. In view of their own teacher shortages and increased enrollments, the public schools have a problem of providing enough good observational experiences. The students in the program have transportation problems as the need increases to use public schools at greater distances from the training institution. 50

The pressure of increased enrollments has created an intensified search for alternative methods of providing for observational experiences. The relevance of this factor to the problem of this dissertation should be established when it is realized that this study is an investigation of a possible alternative to direct observations of teaching in an institution whose present enrollment of more than eleven thousand students is over five times as great as it was less than ten years ago.


Summary

The problem of this study is concerned with "where" and "how" observations of teaching might be accomplished. These two considerations seem to raise immediate questions about the value attributed to direct observation, the nature of the current objectives of observation, the role of the campus school in providing observations, and the effect of the rapidly rising enrollments in teacher-education institutions.

The nearly universal belief among teacher educators that the observation of teaching has inherent value seems to provide the problem of this study with some measure of general interest. In addition, it would appear that the character of the recommended objectives for the observation of teaching indicate that some consideration should be given to the affective aspect of the observation in studies of this type. Finally, there is evidence to show that the campus school, which has provided most of the observational activities in the past, may not be able to withstand the pressures of pyramiding enrollments and the increased emphasis on research and experimentation without detrimentally affecting observation.

Therefore, a strong belief in the observation of teaching seems to be confronted with the inability of many teacher-education institutions to provide the traditional kinds of observational experience. One possible way of solving this dilemma is the major concern of this study.
CHAPTER II

THE PROBLEM

The Basic Problem

The problem which engendered this particular study is basically a conflict between the desire to maintain a substantial number of direct observational experiences in the pre-service phase of teacher-education programs and the seeming ability of teacher education to provide these experiences. It has been pointed out that among teacher educators the desire for direct observations is strong and almost universal. As late as 1965, two investigators, after reviewing the literature relative to classroom observation, stated flatly: "The assumption that observation has value in teacher preparation is still not questioned." Even so, the desire alone for observational experiences is not sufficient to effect these activities.

The apparent obstacles to the implementation or maintenance of direct observations of classroom teaching would include such factors as: (1) the changing role of the laboratory school, (2) the phenomenal increases in teacher-education enrollments, and (3) the insoluble problems encountered when attempts are made to shift the observation

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sites to the public schools. In addition, there are inherent drawbacks to direct observation. Pula has identified the following defects associated with the direct observation of classroom teaching:

1. It is difficult to get more than a few observers in a classroom at any one time.

2. Children tend to react unnaturally to visitors, especially if visitors pay undue attention to a particular child.

3. If visitors are put in an out-of-the-way location so that they do not interfere with normal class activity, their observation is usually limited.

4. Visitors usually have to observe class activity from a single confined position.

5. Discussion during the observation is impossible without disturbing the teaching-learning relationship in the classroom.

6. Cooperating classroom teachers are sometimes difficult to locate.

7. Much time is spent in traveling to classrooms for observation purposes.²

Any combination of these shortcomings could produce the type of conflict which is the concern of this study.

The Significance of the Problem

The significance of the problem is a function of the general concern expressed within the teacher-education community relative to the need for observations of teaching. Many teacher educators feel today the same way Geraldine Murphy felt in 1962 when she said: "The period of observation is, then, a necessary buffer zone between the

²Fred John Pula. "Using Television for Observation of Teaching." Improving College and University Teaching, 16 (Winter, 1968) 58.
study of educational theory and actual teaching."³ Some leading educators believe that observation should play an even more prominent role in the professional laboratory sequence than it has in the past.⁴

Contrasted with this belief in and advocacy of the utilization of the direct observation of teaching are the obstacles to its implementation. Some teacher preparation institutions lack facilities for the direct observation of teaching. Many colleges and universities are discovering that their existing facilities are inadequate or are being taken over by other educational activities. In addition, nearly all schools are experiencing the enrollment increases and associated problems described in Chapter I. Since the desire for observational experiences seems to be widespread and the obstacles to providing observations are encountered by most schools, then the problem of furnishing these experiences should engender a significant degree of general interest among teacher educators.

The Setting of the Specific Problem

The investigation described in this dissertation took place at Wisconsin State University—Oshkosh. The University is a tax-supported institution located at Oshkosh, Wisconsin, a city of approximately 50,000 population on the shores of Lake Winnebago, the Fox River, and Lake Butte des Morts. The school is the largest of nine institutions.

³ Geraldine Murphy, "The Prospective Teacher as Observer," The Journal of Teacher Education, 13 (June, 1962) 151.

comprising the Wisconsin State University System, which is the fifth largest university system in the nation as to full-time enrollment. Control of the state university system as a whole is vested in the Wisconsin Coordinating Council for Higher Education, and the Board of Regents for State Universities.

The University has a history of growth and development similar to that of many teacher-preparation institutions scattered throughout the United States. Founded as a normal school in 1871, the school became a State Teachers College in 1925. With the approval of curricula in liberal arts in 1949, the name of the school was changed to Wisconsin State College--Oshkosh.

During the late 1950's and 1960's the school experienced a rapid growth in enrollment as indicated in Table 1 below. The number of programs offered by the institution also increased, and with the development of several graduate programs, the college was designated Wisconsin State University--Oshkosh in July, 1964.

<table>
<thead>
<tr>
<th>Year</th>
<th>Enrollment</th>
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<tbody>
<tr>
<td>1950</td>
<td>794</td>
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<tr>
<td>1955</td>
<td>1,164</td>
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<td>1960</td>
<td>2,251</td>
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<td>1965</td>
<td>7,133</td>
</tr>
<tr>
<td>1968</td>
<td>11,096</td>
</tr>
<tr>
<td>1969 (projected)</td>
<td>12,400</td>
</tr>
</tbody>
</table>

At the present time, the instruction at the University is encompassed within five schools—the School of Business Administration,
the School of Education, the School of Letters and Science, the School of Nursing, and the Graduate School. The School of Education and the School of Letters and Science each enroll approximately 40 per cent of the more than 11,000 students. The remaining members of the student body are enrolled in the other three schools of the University with the greater portion pursuing studies in the School of Business Administration.

WSU-0 is a coeducational University offering bachelors and masters degrees. Although the School of Education enrolls only 40 per cent of the total student population, over 50 per cent of the degrees granted by the University are in the field of education. During the past year (1968-1969), the faculty granted 1277 baccalaureate and 88 masters degrees. Slightly more than one half (644) of the bachelors degrees were in elementary or secondary education, and all of the masters degrees were either Masters of Science in Education or Masters of Science in Teaching.

Most of the students enrolled at WSU-0 are residents of Wisconsin, although, since 1965, increasing numbers of out-of-state and foreign students have been attracted to the school. At the present time, non-resident students comprise from ten to fifteen per cent of the student body.

Two factors make it difficult to formulate generalizations relative to the quality of WSU-0 students. First, prior to 1960 nearly all students resided in east-central Wisconsin which is primarily a rural or small city region. Since 1960, significant numbers of students have come from the urban areas of the Southeastern part of the state and from Northeastern Illinois. These students have produced changes in the overall cultural background and level of preparation of the
incoming classes. Second, the development of new programs at the University during the last decade have, from time to time, attracted large blocks of students interested in these particular courses of study. In some instances, these rather homogeneous groups of students have significantly affected the nature of the "average" enrollee.

Attempts have been made each year to analyze the incoming freshman classes, but few of the statistics obtained relative to the structure of the classes remain stable from year to year. The most meaningful information appears to emanate from the University's participation in the American College Research Program. Investigations by the WSU-O department of Testing and Research Services show that the mean ACT Composite score of incoming freshmen improved slightly from 1960 to 1965. Since 1965, that particular score has remained quite stable, and when it is compared to the scores of the nearly four hundred schools participating in the ACT Research Program, it consistently ranks near the sixtieth percentile. In general, comparisons with schools participating in the ACT Research Program reveal that Wisconsin State University--Oshkosh ranks somewhat above the group average.

Since its founding in 1871, the University has had a tax-supported, college-controlled, on-campus laboratory school. For at least the last two decades the Campus School has consisted of one class at each grade level, Kindergarten through Ninth Grade. The enrollment of the Campus School, approximately 250 students, has not varied significantly since World War II. The functions of the Campus School have been modified considerably during the last twenty years, and the School has encountered most of the problems typically faced by the campus schools of today. The current functions of the laboratory
school pertinent to the specific problem of this study will be discussed in detail in the following section.

The Specific Problem

The required mathematics program for students in elementary education at Wisconsin State University—Oshkosh consists of two sequential one-semester content courses followed by a content-methods course. All of the courses are designed to meet the specific needs of prospective elementary school teachers, consequently, only elementary education majors are permitted to enroll in these courses. The initial course, 67-203 (2 credits), is intended to introduce the student to elementary set theory, the concept of number, the sets of natural, whole, and positive rational numbers together with the usual operations of arithmetic defined on these sets. The properties of addition, subtraction, multiplication, and division are considered. Bases of numeration, inequalities, topics in number theory, and some measurement concepts complete the list of topics normally treated in this course.

The second content course, 67-403 (3 credits), is employed to continue the development of the number system by reviewing the concepts associated with the positive rational numbers and by extending the student's understanding of the set of negative rational numbers. This is followed by a consideration of the set of real numbers. The remainder of the course includes topics in algebra, geometry, and logic.

The final course in the sequence, 67-603 (2 credits), is entitled Content and Methods of Elementary Arithmetic. This course is called a "two plus one" course because it meets twice a week for the complete semester and it convenes an additional, or third, day per week
for the first twelve weeks of the term. The dozen class-hours represented by the additional meetings scheduled during each of the first twelve weeks are designated as "laboratory" sessions.

The "non-laboratory" meetings are regularly employed to investigate the literature dealing with the psychological principles underlying the learning and teaching of contemporary elementary school mathematics, to analyze the "discovery" method of teaching elementary school arithmetic, and to compare the various types of discovery learning and teaching with a postulated "traditional" method of learning and teaching. The fundamental properties of the operations of arithmetic and the basic mathematical concepts developed in the pre-requisite mathematics courses, i.e., 67-203 and 67-403, are identified and examined in various elementary school mathematics textbooks. A variety of methods of developing these basic concepts and principles in the elementary school classroom are treated. Considerable attention is paid to the nature of the objectives of "modern arithmetic" programs with particular emphasis on behavioral objectives. In these classes, approximately half of the instructional activity is lecture-demonstration with the remainder of the time devoted to small group (three or four students) investigations of specific problems related to the teaching of arithmetic. The results of these small group investigations are revealed to the entire class through teaching incidents, role playing, panel discussions, or any one of several other vehicles deemed appropriate to the particular problem under consideration.

Some of the "laboratory" sessions are used to describe and demonstrate teaching aids such as the overhead projector, the abacus, and the feltboard. An important function of other "laboratories" is to
investigate and analyze typical elementary-school student computational errors and attempt to ascertain the mathematical misconception possessed by the student which might account for the observed erroneous calculation. The heart of the "laboratory" sessions is, however, a series of classroom observations at various grade levels in the University Campus School.

One of the chief benefits derived from the classroom observations has been to "convince" prospective elementary school teachers that appropriate concepts and skills of modern mathematics can be acquired by elementary school children. Very often, instructors in these courses have detected a distinct change in the expressed views of these soon-to-be teachers toward modern mathematics after they have observed elementary school children working, apparently successfully, with the new mathematics.

This change in viewpoint is understandable. Most of these college students had their first experiences with the new mathematics in the content courses 67-203 and 67-403. For many of these students, the initiation was accompanied by difficulties in adjustment to the strange vocabulary and to the modern approach to learning mathematics. As a result of these experiences, a significant number of these students enter the content-methods course strongly believing that elementary school children are incapable of learning or understanding "modern arithmetic." This notion is often revealed by questions of the following type: "Can second grade students learn this stuff?" or "I don't understand the distributive property very well and I've had it in three courses! How in the world can I expect a third or fourth grade student to understand it?" These kinds of questions are expressed frequently
during the early stages of the content-methods course. After several classroom observations, the tenor of the questions seems to change from "Can youngsters learn 'modern mathematics'?" to the more relevant questions--"How do youngsters learn 'modern mathematics'?' and "How should 'modern mathematics' be presented to elementary school students?" The change is often quite dramatic! This apparent shift in viewpoint is one of the principle reasons for believing that observations of teaching are necessary concomitants of these particular content-methods courses concerned with the teaching of arithmetic.

Although the observation of the teaching of arithmetic appears to play an essential role in the laboratory phase of these content-methods courses, each year it is becoming more difficult to provide these experiences. First, the rapid increase in WSU-O enrollment has increased the number of classes seeking observations or teaching demonstrations in the laboratory school. Second, the Campus School consists of one class at each grade level K-9, and it is precisely the size it was twenty years ago when the "Teachers College" enrolled less than one seventh of the number of students enrolled in the School of Education today. Since eight different subject matter areas require these "two plus one" methods courses, there exists a great disparity between the number of college classes requesting observations and the number of elementary school class periods available for demonstration purposes. Third, the role of the WSU-O Campus School is in the process of being re-defined. One relatively new function of the Campus School is to provide pre-service experiences for teaching interns. The intern program at WSU-O has expanded rapidly during the last few years with a disproportionate drain on the time and energy of the Campus School staff
and facilities. Also, there has been a significant increase in research activity in the Campus School since the advent of graduate programs during the early 1960's. In addition, psychology classes, social foundations classes, and orientation to education classes are consuming substantial blocks of time for observation and participation activities in the Campus School.

The situation has reached a point where it is practically impossible to schedule desired observations at appropriate times. During the last two years, one hundred twenty-six observations of the teaching of arithmetic were requested. Generally, these requests were submitted four to six weeks in advance of the date desired for the observation, yet, due to conflicts, less than one third of the observations could be scheduled as planned. In some cases, it was necessary to employ fewer than the desired number of observations for some of the classes. There is little question that the problem of providing for observations of teaching in the Campus School at WSU-Oshkosh is acute and the future of this kind of activity at this University appears to be bleak. This predicament is the "specific problem" of this dissertation.

Definitions

Before proceeding to an investigation of some of the attempts to solve problems similar to the one just described, there are certain definitions which should be stated. The literature is replete with terms employed to identify specific kinds of observation situations. The following definitions and the indicated synonyms may help the reader understand the manner in which some of these seemingly diverse terms have been utilized by researchers in the past, and, more to the
point, the meanings to be assigned to these terms within the context of this dissertation.

I. Live Observation: An observation of teaching-learning which occurs with the observer situated in the classroom while the observed activities are taking place.

Synonyms: Direct Observation, In-person Observation, In-class Observation, Face-to-face Observation, Classroom Observation.

II. Vicarious Observation: Any observation of teaching-learning which is not a "live observation."

Synonym: Indirect Observation.

A. Filmed Observation: A vicarious observation situation in which the observer views a teaching-learning incident previously recorded on motion picture sound film.

B. Closed Circuit Television Observation: A vicarious observation situation in which the observer, located at some point remote from the classroom in which the observed activities are taking place, views a teaching-learning incident, as it occurs, over a closed circuit television hook-up.

C. Video Taped Observation: A vicarious observation situation in which the observer views a teaching-learning incident previously recorded on video tape.

D. Kinescope Observation: A vicarious observation situation in which the observer views a teaching-learning incident previously recorded on motion picture sound film. The film was produced by focusing the camera on a television screen.

Review of the Related Literature

The search for solutions to the problem of providing direct observations of teaching appears to have been initiated by attempts to transfer observational activities from the on-campus laboratory schools to the public schools. For limited numbers of off-campus observers, this arrangement seemed to be workable and effective. When it became
apparent that large numbers of student observers would need to be accommodated off-campus, the reluctance of many public school teachers to provide observations together with the logistic and administrative problems encountered by the college authorities soon indicated that the shift to the public schools was a less than satisfactory solution.

A survey of the literature pertaining to the utilization of vicarious classroom observations reveals that closed circuit television and films were being employed as substitutes for live observations by a number of schools soon after 1950. The decisions to acquire the equipment and make use of it were, presumably, based primarily on a priori rather than experimental evidence, because there were few, if any, relevant experimental studies conducted until the late 1950's.

The increased interest of educational researchers in the problem of observing teaching-learning appears to have been linked to the dramatic upsurge in enrollments at numerous teacher-preparation institutions across the country and to the equally dramatic influx of federal funds supporting media research via the Title VII program of the 1958 National Defense Education Act. Almost all of the individuals who reported research referred to the mounting enrollments when describing the need for the study, and nearly half of the studies to be reported below were funded by the United States Office of Education under Title VII.

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Although one might expect the literature to have revealed a massive and sustained attack on this widespread problem of finding "substitute observations," no such thing appears to have happened. A flurry of activity between 1958 and 1964 produced in the neighborhood of twenty studies aimed at the observational problem, but only a few relevant experiments have been conducted during the last five years.

Lesser and Schueler noted this apparent lack of activity in the general area of media research in 1966. They suggested that one explanation for this deficit could be that "... only a small portion of media studies in teacher education have appeared in the published literature, and unpublished research and mimeographed copies are not always made available." Later in the article they identified a much more cogent reason. They said:

Rigorous empirical research on the applications of new media in teacher education is scarce, and the studies which do exist are primarily of recent origin.

The scarcity of empirical research is somewhat surprising in view of the considerable number of organizations in which technical and professional resources are now available. Recent publications describe formidable lists of institutions with various media facilities. It is not clear why so little systematic research has emerged from these many sources, but it is perhaps true that when the installation of expensive equipment precedes rather than follows the demonstration of its value, subsequent discussions tend to contain justification and testimonial rather than objective assessment.

These authors went on to suggest that the predominance of experimental results showing non-significant differences may have "persuaded" numerous investigators not to publish.

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7 Gerald Lesser and Herbert Schueler. "New Media Research in Teacher Education." AV Communication Review, 14 (Fall, 1966) 320.

8 Ibid., pp. 320-321.
The experimental studies related to the problem of this dissertation fall naturally into three main categories: (1) comparisons between filmed (or kinescope recordings) and direct observations, (2) comparisons between televised and direct observations, and (3) simultaneous comparisons involving filmed, televised, and direct observations.

There are a few investigations which do not fit into any one of these categories. Occasional attempts have been made to find a substitute for live observations which did not employ "moving pictures" or television, but these attempts have been extremely rare. Mizer\textsuperscript{9}, for example, conducted an experiment utilizing edited audio tapes only, and he discovered that students would not accept the tapes as a substitute for observation. Since these kinds of experiments occur infrequently, and since they appear to offer little help in solving the problem under consideration, they will be excluded from this review.

No attempt will be made in this review to consider those studies concerned with micro-teaching, simulation, or interaction analysis. There are several reasons for this decision. One reason is that the format of each of these techniques differs radically from the format associated with the traditional observations of teaching. Closed circuit television and films can be employed to produce reasonable facsimiles of the "traditional" observations of teaching, but micro-teaching, simulation, and interaction analysis prescribe entirely novel roles for the observer. The active role of the observer in a simulated or micro-teaching situation contrasts sharply with the generally more

passive role of the "traditional" observer. The relatively narrow focus of attention, i.e., verbal activity alone, inherent in an interaction analysis situation divorces it from the usually broad scope of interest associated with "traditional" observations of teaching.

A more cogent reason for rejecting micro-teaching, simulation, and interaction analysis is that none of the three holds much promise in terms of providing a solution for the specific problem of this study. For example, simulation and micro-teaching delineate individualized instructional situations, hence the problem of increased enrollments would remain unresolved. Also, interaction analysis requires the observation of teaching as an initial condition, therefore its implementation would still require some solution to the very problem under consideration. For these reasons, this review will be confined to those studies which dealt with comparisons of direct observations with filmed and/or televised observations.

Filmed versus Live Observations

One of the first investigations aimed at testing the effectiveness of vicarious observations involved the use of films. During the academic year 1957-1958 Robert Patrick conducted a carefully designed study which pitted 21 specially prepared 50-minute films of classroom activities against face-to-face observations. One hundred twenty secondary education majors in a teaching methods class were randomly assigned to control and experimental groups. Experimental students had

all of their observations via films, while the members of the control group had live observations. All students took an attitude toward secondary teaching scale, an understanding of secondary methods, and an educational psychology test as pre- and posttests. Students also completed an evaluation of their observational activities, four essay tests, and an instrument designed to evaluate the instructor. Student interviews were also conducted.

The results of the objective tests indicated that although there appeared to be no significant difference between the two groups relative to their understanding of the nature of teaching, the film group obtained significantly greater value from the series than did the control group. The essay tests revealed that the experimental group acquired a better understanding of the teaching process and exhibited a more creative approach to teaching. Follow-up studies concerned with the success of these individuals in student teaching demonstrated that the students who had been members of the film group were rated significantly higher by their supervisors than those who had face-to-face observations.

Subsequent replications and extensions of this experiment by Patrick brought the total number of students involved to 390 and produced results comparable to those obtained from the initial investigation. These follow-up studies also revealed that first-year teachers who observed via films were rated significantly higher by their supervisors.

supervisors than were their counterparts in the control group. The beginning teachers from the experimental groups also evidenced significantly more favorable attitudes toward their supervisors than did those individuals in the live-observation group.

These investigations by Patrick and others are considered to be significant because: (1) they produced some of the first experimental information concerning vicarious observations, (2) they were carefully planned and administered, and (3) they represented one of the infrequent attempts to utilize a longitudinal design. The use of student teaching behavior and first-year teaching performance as criteria identify these works as important contributions to media research.

Fulton and Rupiper used films as a substitute for live observations in a study conducted in 1961. In a well-designed, well-executed study, these men compared students using films and slides with others observing classes directly. These comparisons were made in three different types of education classes, i.e., The School in American Culture, Human Growth and Development, and Educational Evaluation and Guidance. The time spent observing was the same for both the "vicarious" and "direct" observers.

The criterion variables in this particular study were achievement and attitude. The Sims Social Class Identification Occupation Rating Scale was employed as a pretest, while the School and College Ability Test and Minnesota Teacher Attitude Inventory were used in a pre- and

A posttest design. Carefully constructed and adequately reported achievement tests were prepared for each of the three classes.

Except for one class, an analysis of variance indicated no significant differences among the three courses for either of the treatments. The exception noted above involved the introductory professional education course, The School in American Culture. At this introductory level, the film and slide group scored significantly higher on the posttests than did the corresponding members of the direct-observation group. The authors concluded that film and slides were more effective than direct observations when used in basic professional courses, but that in upper-level professional education courses neither method could be judged superior to the other.

Employing varying amounts of viewing time, Painter\(^{13}\) compared locally produced films of unrehearsed classroom activities with live observations. The experiment extended over a three semester period and involved two experimental groups contrasted with two control groups during each term. The initial trial had 46 control students make six (6) live observations while 44 experimental students watched two (2) films. The second semester experiment matched 61 control students observing six (6) times directly with 69 experimental students viewing six (6) films. The third trial involved 60 control and 67 experimental students with nine (9) direct and nine (9) filmed observations, respectively.

Content-type achievement tests were used for criterion measurements. Nominal, although significant, mean differences in favor of the film group were noted at the conclusion of the second trial, but pooled scores for all three experiments failed to produce significant differences between the two groups.

Wedberg\textsuperscript{14} employed various combinations of direct observations and films (including slides) in an attempt to measure the effectiveness of vicarious observational experiences. His avowed purpose was to investigate the "instructional and administrative efficiency" of various modes of classroom observation. He established three groups of students: a control group which had 30 hours of direct observation; an experimental group which had 10 hours of programmed observation utilizing sound films, sound filmstrips, slides and tape, and tape recordings followed by ten hours of direct observation; and, a second experimental group which received the same treatment as the previous one minus the 10 hours of live observations.

This study concentrated on subject matter learning. Posttests seeking factual information acquired during the period of observation were used to measure the criterion variable. An analysis of the post-test scores revealed that both experimental groups achieved significantly higher mean scores than the control group (.01 level), but the two experimental groups did not differ significantly from each other.

Wedberg concluded that the film and slide treatment was more effective

than direct observation in teaching factual information about the role of the teacher.

Experiments utilizing kinescope recordings have been included in the "film" category because most experts assert that it is nearly impossible to distinguish between the two types of presentation. When discussing this point in the *Handbook of Research on Teaching*, A. A. Lumsdaine said:

... The respects in which films are likely to differ instructionally from kinescopes or video-taped recordings of "live" televised instruction probably lie more in philosophy and practice of production than they do in inherent media differences.

... For most instructional purposes, then, the inherent instructional properties of film and of recorded television presentations can be considered substantially identical.\(^{15}\)

Leslie P. Greenhill, Director of the University Division of Instructional Services at The Pennsylvania State University, made precisely the same point in his introduction to Reid and MacLennan's collection of research abstracts entitled *Research in Instructional Television and Film*.\(^{16}\)

The only actual difference between kinescope and regular film viewing is related to the quality of the film itself and this may be superior for either type at any given time.


In 1962, Charles Nearing performed an experiment designed to compare kinescope recordings with classroom visitations. The study involved 418 students who were about equally divided between morning and afternoon classes. Half of the morning students and half of the afternoon students saw a 2-hour presentation of kinescopied classroom activities. The remaining students made all-day visitations to nearby public schools where they observed teaching-learning in one or more classrooms for approximately five hours. The main comparisons made in the study were: time of day, instructor, and method of observation.

Six instruments were employed to measure the criterion variables. They were: the Minnesota Teacher Attitude Inventory, the Misconceptions of Education Scale, the Career Plans Questionnaire, a Course Evaluation Scale, Course Grade, and an Evaluation of Observation Experiences Scale.

Nearing found no significant differences between the two groups on the attitude instruments. He did find the kinescope group scoring significantly higher on the Career Plans Questionnaire and significantly lower on the evaluation of observational experiences. The scores describing attitudes toward teacher-pupil relationships, career plans, and course evaluation revealed substantial instructor influence, and students taking afternoon classes generally achieved significantly higher course grades than those who attended morning classes.

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This study appears to have at least one major drawback. The treatment was minor when considered in terms of the criterion measures. It seems inconceivable to this writer that a 2-hour program of kinescope recordings or five hours of classroom visitation in a single day would significantly affect career plans, course grades, attitudes toward the course or toward children. The expected results in each case must logically be "no significant difference" for such "one-shot" treatments. Any differences obtained would probably be better explained in terms of contaminating variables rather than the treatments. Any conclusions based on this study must be highly suspect.

Another study involving a comparison of kinescope recordings and classroom visitations was reported by Stochl in 1964. He structured the experiment to yield information about the effectiveness of the observational media as well as any differences which might be attributed to the use of more than one demonstration teacher. This was accomplished by having the regular methods course instructor and the elementary school teacher who normally provided demonstrations both prepare and present live demonstrations and kinescope recordings of demonstrations. This arrangement produced four treatments, i.e., methods teacher "live," methods teacher "kinescoped," elementary teacher "live," elementary teacher "kinescoped."

One hundred fifteen students were employed as subjects by Stochl during the spring semester of 1961 and 61 students took part in a continuation of the study during the fall term of the same year. Five

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demonstrations were scheduled at two week intervals during each semester. Miller Analogies test scores, grade point averages, and mathematics usage tests were employed as pretests. The criterion measures were the course final examinations and a specially constructed film test on the methodology of mathematics teaching. An analysis of these data indicated that none of the major null hypotheses were rejected. The repetitious occurrence of "no significant differences" between control and experimental groups led the author to conclude that kinescope recordings were at least as effective as live observations, and that kinescopes could be used as a supplement, if not a replacement for, direct observations.

**Closed Circuit Television versus Live Observations**

One of the earliest experimental comparisons of these two methods of observations was performed under the direction of William R. Rogers and reported in the periodical literature by John C. Woodward. The design of this study reflects the authors' intention to evaluate closed circuit television observations as a supplement to rather than a replacement for live observations. This is revealed by the nature of the experimental treatment. The students were divided into five subsets, three experimental and two control groups. Each of the three experimental groups had twelve and one half hours of closed circuit television observation plus varying amounts of direct observation. One group had television plus 12 hours of direct

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observation, a second group had television plus 25 hours of in-person observation, and the third had television plus 37 hours of live observation. The two control groups each had 50 hours of face-to-face observation.

Control measures included college scholarship, College Qualification Test scores, and faculty ratings of teaching potential. The criterion scores were essentially teacher ratings of the students' performance during the period of in-person observation and during student-teaching. The ratings were obtained through the use of locally established rating scales.

An analysis of variance indicated that there were no significant differences among the five groups on either of the criterion measures. Woodward concluded that closed circuit television could be used to relieve many of the problems usually associated with direct observation programs. He also asserted that in-person observations could be reduced by seventy-five per cent without any apparent ill effects.

Rumford investigated the effectiveness of "total teaching via television" by having experimental students in elementary school methods classes receive both instruction and observations by means of closed circuit television while the control students viewed the same activities seated in the television studio from which the broadcasts originated. The classes convened for two hours each day, five days per week, with half the time devoted to observation.

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Rumford considered two dependent variables in his assessment of the effectiveness of the contrasted methods of observing demonstration teaching. One criterion consisted of the scores on daily observation reports, and the other was related to scores obtained on an objective test designed to determine the reaction of students to the differential treatment. An evaluation of these scores revealed that "no significant differences" existed between the two groups. The author of the study concluded that televised observations were generally as effective as live observations.

In a study conducted during the spring semester of 1959, Voorhies found that student observers preferred three simultaneous independent camera views of the observed activities rather than fewer. His study involved 76 students enrolled in mathematics, language arts, and social studies methods classes. Criterion data were obtained through the use of a numerically scaled check list, an interview guide, and three opinionnaires. In addition to the preference of the student observers noted above, Voorhies found that students judged direct observation to be slightly superior to closed circuit television for observing classroom instruction, but, in general, they accepted closed circuit television as an effective alternative and/or supplement to direct observation.

An attempt was made by Chabe\textsuperscript{23} to evaluate the use of study guides with different types of observations. Eighteen students were divided into three groups. Four students were provided with lesson guides and sat in the classroom during the conduct of the demonstration lesson. The 14 remaining (experimental) students viewed the same lesson demonstration over closed circuit television. Six members of the experimental group used the same lesson guides employed by the in-person observers. These six individuals were isolated from the other eight television viewers who were not provided with lesson guides.

Prior to the initiation of the experiment, all of the subjects had been thoroughly instructed as to the nature of the objectives of social studies teaching. During the observations, observers were required to record instances in which observed activities could be judged to meet the objectives of social studies instruction. The author analyzed these responses and concluded that guided television observation was nearly as effective as guided classroom observation, and that television viewers with guides were almost twice as effective as those without the guides.

There are several facets of this study which tend to discredit any conclusions which the author might formulate. The small number of students is a negating factor, and the unexplained division of the subjects into groups of 4, 6, and 8 seems to require some sort of justification. In addition to these weaknesses, the criteria measures

appear to lack precision. For example, the student raters were asked to record: "(1) the understandings (generalizations) they formulated which children could also supposedly formulate, (2) the skills children developed; (3) the attitudes children formed, and (4) the pupil appreciations which grew out of the lesson on agriculture and manufacturing in the modern South." Seemingly, it would be almost impossible to validate responses to those items. In general, this study seems to be a convincing demonstration that lesson guides are effective teaching agents and little else.

Employing a pre- and posttest design, DeViney sought information about learning and attitudes while using televised observations as the treatment. This investigation involved 719 North Texas State University students enrolled in the first professional courses of the sequence for majors in elementary education during the academic year 1961-1962. The experimental groups had one televised observation per week for a total of seven weeks, while the control groups had a similar number of direct observations.

Two content tests were administered to measure academic achievement and subscores from these tests were employed to measure problem-solving ability. The Minnesota Teacher Attitude Inventory was used to measure attitudes toward the pupil-teacher relationship. No significant differences were found between experimental and control groups with any


of the criterion measures during either of the two semesters. The differences, although nonsignificant, generally favored the control groups.

One of the most carefully designed and executed experiments was conducted by Ronald Sykes\textsuperscript{26} in 1964. This study had an interesting feature: a "situational problems test" was employed to measure the students' ability to apply what had been learned to particular problem situations. In this study 88 students were randomly assigned to three groups, i.e., no observations (29 students), face-to-face observations (30 students), closed circuit television observations (29 students). The experimental groups watched six 45-minute art lessons over a six week period. One group viewed the demonstrations in the classroom while the other group observed the same lesson over closed circuit television in a nearby room. The television observers watched three monitors linked to three different cameras. Each observation was preceded by a 15-minute orientation period and followed by a 10-minute review conducted by the demonstration teacher.

An analysis of covariance applied to the scores obtained from the situational problems test indicated no significant differences between the scores of the two observational groups, but both of these groups obtained significantly higher scores (.001 level) than did the members of the group which had no observations at all.

This study appears to be characterized by effective control of variables likely to contaminate the results. The use of three viewing monitors indicates that the investigator probably benefited from the results of previously described studies, i.e., Voorhies' study, and the use of a "no-observation" group lends credence to the significant gains achieved by the experimental groups.

Closed Circuit TV versus Films versus Live Observations

One of the earliest investigations involving all three types of observations was a comprehensive team effort executed at the University of Minnesota in 1959-1960. Three men were involved in this evaluative study. Frederick Abel\(^27\) concentrated on "subject matter mastery" and "application" of achieved learning. Orrin Gould\(^28\) evaluated the students' "perception of the educational value" attributed to the observational experiences and the students' "evaluation of the effectiveness" of the modes of presentation. Franklin Thompson\(^29\) dealt with the affective or attitudinal aspects of the study. The three dissertation reports are linked since all three men obtained their data from the same set of subjects exposed to the experimental treatments.


The experiment was designed to compare the effectiveness of televised, filmed, and live observations. Six sections of "Introduction to Secondary School Teaching" were randomly assigned to one of three treatment groups, i.e., television observations, filmed observations, direct observations. Each class observed five times using its primary mode of observation and one period using each of the two other methods. A specially prepared pretest and Miller Analogies Test scores were employed to establish the initial status of all groups.

Abel used midterm and final examinations as criterion variables as well as the standardized test battery by Horrocks and Troyer, Tests of Human Growth and Development. He found no significant differences among the three groups.

Gould employed "student reports of perceived educational significance during observations," a film test of "observational skills," and reports of "observational experiences" as criterion measures. He found no significant differences among groups on any of the instruments, but concluded that students tended to favor direct observation over television observation with the preference for either live or televised observations over filmed. He asserted that the three modes of observation tended to supplement rather than replace each other.

Thompson measured attitudes toward children, toward method of presentation, and toward teachers by means of a "course rating scale" and the Minnesota Teacher Attitude Inventory. He found that the type of treatment did not influence student attitudes toward children; students preferred direct observations to television and televised observations to films; and, that student attitudes were more often influenced by the college instructors than by the observational methods employed.
In general, the analyses associated with each of these reports revealed "no significant differences." One factor which might have had some bearing on these results was the "mixing" of the treatment variables. This "mixing" could negate attempts to ascertain the distinct influences of a specific treatment. Note that each subject observed five times with an assigned "primary" method of observation and once with each of the other two modes. It seems unlikely that a single observation involving a "secondary" mode would provide sufficient exposure to influence the final result in its favor. On the other hand, when one considers that nearly one third of the total treatment is not of the "primary" type, then these two observations could easily have diluted whatever influence the "primary" treatment might have had.

A year after the previous study was completed, Adolphsen conducted a study which was essentially a replication of Gould's phase of the initial experiment. This replication differed from the original investigation by varying group size and number of observations. Adolphsen found that the ability of the prospective teacher to perceive specific teacher behavior was related to the extent of the observational experience but not to the viewing medium.

Another doctoral candidate at the University of Minnesota, Daniel Neale, also attempted to compare the effectiveness of films, television, and direct observation. Neale's experiment was primarily

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a replication of Thompson's earlier work with minor variations in group size and extent of observation. The criterion variables in Neale's study were attitudes and learning. He used the following measuring instruments: (1) the Minnesota Teacher Attitude Inventory, (2) the Bowers Teacher Opinion Inventory, (3) the course examinations, and (4) student ratings of the course. An analysis of the student responses and examination scores revealed few significant differences between the control and experimental groups. The main conclusion was that direct observers and the television observers tended to favor their experiences over the film viewers. This result corroborates a conclusion reached earlier by Gould and Thompson.

Stoller and others conducted a carefully planned study contrasting closed circuit television, kinescope recordings (films), and live observations. The investigation involved 288 female Hunter College undergraduates enrolled in a course entitled "Elementary Education." A specially prepared objective test was used as a pre- and posttest to measure any gain in understanding of teaching methodology acquired in the course. An essay examination was employed to assess the students' ability to critically evaluate observed classroom activities.

The authors utilized a multivariate statistical design to detect various interactions. Even so, the general result of all tests was "no significant differences." The one exception to this general pattern was the result of the Lesson Evaluation analysis. Here it was demonstrated that "the different observational techniques will produce different

effects upon learning and specifically, that the kinescope observation is superior to TV observation which, in turn, is superior to direct observation."\textsuperscript{33} It should be noted that the only important significant differences were obtained employing an essay-type examination. The extreme difficulties encountered in constructing reliable essay examinations tends to limit the degree of confidence one might have in this result. In addition, it is interesting to note that this result reverses the order of media preference detected earlier by Gould and Neale.

Summary and Comments

There are several aspects of the reported studies which appear to be characteristic of the overall experimental activity in this particular area of teacher education. First, there is the regularity with which "no significant differences" occur. This phenomenon may in fact be due to an essential sameness among filmed, televised, and live observations, but it appears to be more a function of the inability to establish appropriate criteria and develop precise measuring instruments.

Greenhill said:

One of the main difficulties of such studies is the selection of appropriate criteria for evaluating the effectiveness of the methods being compared. In some instances, where observations have been a part of a required course on methods of teaching, the course examinations have been used as the criteria. In such cases there may be very few questions on which teacher demonstration observation has a direct bearing.\textsuperscript{34}

Several of the investigations reported here do use course examinations as criteria, while many others fail to provide adequate information

\textsuperscript{33}Stoller et al. op. cit., pp. 192-193.

\textsuperscript{34}Reid, op. cit., p. 6.
about the reliability and validity of the "specially prepared" tests which were employed.

A second feature of the research activity directed toward the problem of providing observations is the absence of replicating studies. Lesser and Schueler attribute this deficit mainly to the lack of a sufficient number of studies and the rather recent interest in the problem. They said:

Given both scarcity and recency of media research, few replicated findings have as yet accumulated. The absence of replication and cross-validation of results is perhaps the most conspicuous characteristic of research on media usage in teacher education.35

This statement was made in 1966. The situation with respect to the observation of teaching has not improved during the last three years. Since 1966 the emphasis of teacher education research activity has shifted to programmed instruction, simulation, micro-teaching, and to some extent, interaction analysis. Very little interest in observation having a "traditional format" is currently in evidence. Certainly no interest in replication studies is evident. Another factor which has tended to thwart attempts to replicate studies has been the profusion of "specially prepared" tests, "specially prepared" films, etc. The uniqueness inherent in these "special" situations makes efforts at replication all but impossible. It seems significant that all attempts at replication have been confined to a given school, e.g., University of Minnesota, where crucial measuring instruments and experimental conditions can, within reasonable limits, be duplicated.

A third feature of the literature reported in this study is the fundamental nature of the dependent variables selected by the investigators. Nearly all investigators, not unexpectedly, sought evidence concerning the achievement of some sort of content or factual information. What seems unusual is that a great many of the experiments attempted to measure changes in observer attitudes and opinions of the observational experience. This seems to be an appropriate area of investigation. Unfortunately, in many instances the instruments used may well have been too gross to differentiate between treatments. The Minnesota Teacher Attitude Inventory, for example, was used by a great many investigators to measure attitude changes. This instrument is designed to measure the subjects' attitude toward the "teacher-pupil relationship" which is at best a multifaceted phenomenon. It would seem that since attitudes are generally presumed to be directed toward rather specific psychological constructs, instruments designed to measure very specific attitudes might have produced more fruitful results.

In summary, there seems to be an insufficient amount of experimentally derived information about the nature and utilization of vicarious observational experiences. Replications of existing studies are conspicuous by their absence. Most of the studies already performed have produced encouraging, but inconclusive, results. Seemingly, the repetitious occurrence of "no significant differences" has been regularly interpreted by researchers to mean that experimental and control treatments are "equally effective," but this seems to be an illogical conclusion for most of the statistical designs employed. While the problem appears to require a great deal of investigation, there has been an almost complete cessation of research activity directed toward
providing information about the relationship between "vicarious" and "direct" observational experiences.

When all of the above factors are considered in context, there still appears to be sufficient justification for recommending further experimental inquiry concerning the potential utilization of "indirect" experiences in place of "live" observations. The results which would emanate from these investigations should provide the decision maker with the information needed to select the most appropriate solution for his specific problem. Unless this type of information is made available, it would seem that decision making would remain mere guessing.
CHAPTER III

PROCEDURES AND DESIGN OF THE STUDY

A Proposed Solution for the Specific Problem

The review of the literature illuminated several facets of the problem of providing for observations of teaching-learning in teacher-education programs. For one thing, the problem itself appears to have been recognized as a significant one about a decade ago, because the first attempts to experimentally evaluate substitute activities for live observations were initiated then. A second thing noted by this reviewer was that the duration of research interest in this problem was relatively short. The earliest studies were reported in 1958 and the last important ones appeared in 1964 or shortly thereafter. Practically no research activity dealing with vicarious observations was detected after 1965.

Several things probably contributed to the abrupt halt of the research activity aimed at investigating vicarious observational experiences. Many studies produced nonsignificant differences between experimental and control groups. In most instances, this led investigators to conclude that the experimental and control treatments were equally effective. Thus, one could consider the problem solved. Another possible reason for the decline in research activity is linked to financing. In 1958, it was relatively easy to obtain federal money to support this kind of research, but in recent years these funds are much less readily
available. Currently, these funds appear to be diverted to other areas of interest within the broad field of audio visual education, e.g., simulation and micro-teaching. Finally, as increasing numbers of institutions acquired closed circuit television systems and other expensive equipment, it became imprudent for these schools to risk demonstrating the ineffectiveness of this equipment through evaluative studies, especially when the acquisition of this hardware could easily be justified with a priori arguments.

The third point made clear by the review was that nearly all attempts to provide vicarious observations utilized films, closed circuit television, or both. In general, films and closed circuit television were judged to be equally effective. No single ordering of films, television, and live observation based on the efficacy of the media was found to be consistently superior to any other.

Finally, the lack of replication studies is an important feature of the body of research pertinent to the problem of providing observations of teaching. This deficiency is probably due in great part to the utilization of specially produced films and criterion measuring instruments which were not available to individuals who might have wished to conduct replications of the reported experimental investigations.

Probably the most significant outcome of the literature review was the realization that none of the experimental work to date offered a solution for the specific problem existing at Wisconsin State University-Oshkosh. WSU-Oshkosh does not have closed circuit television facilities, nor does it have personnel or equipment for the production of films. Thus, since nearly all the evaluations of vicarious observational experiences utilized closed circuit television or
specially produced films, even the most decisive results in favor of the experimental treatments would have left the problem at WSU-O unresolved.

One avenue of inquiry ignored by most investigators to date has been the evaluation of films which depict teaching-learning situations and are available from state, regional, or national rental agencies. While there may be various reasons for the researcher's lack of interest in these kinds of films, the fact remains that only one reported study employed this type of audio visual medium as a substitute for live observations.

Assuming the availability of appropriate films, one might suggest several potential advantages to the pursuit of this line of inquiry. First, almost any institution could devise and conduct an investigation because funding would not be a crucial problem. Second, the only equipment needed by the institution using the films would be an ordinary motion-picture film projector. Third, if experimental investigations succeeded in demonstrating the utility of such films, any school would have easy access to them. Fourth, since the films would be widely available, replication studies could be conducted with ease. For these reasons and the fact that an excellent series of ten "content-methods" films dealing with the teaching of elementary school mathematics have recently been produced and made available to the public, this writer proposes to study the relative effectiveness of a set of commercially produced films and live observations. At the present time, these kinds of comparisons appear to offer the only reasonable hope for a solution to the problem at WSU-Oshkosh and for analogous problems at institutions similarly situated.
The Questions

It would seem logical that any substitute for live observations must be evaluated in terms of those variables deemed relevant to the educative contribution attributed to the live observations. Thus, an attempt will be made to identify some of the most significant contributions attributed to the classroom observations which form an integral part of the content-methods course, 67-603, described in Chapter II.

Probably the most important function of the observations in 67-603 is related to the apparent change in the student-observers' attitude toward modern mathematics. Seemingly, the observations serve to convince the doubtful observer that elementary school children can acquire the mathematical skills and concepts associated with the new mathematics programs. This, in turn, appears to help reduce the negative attitudes toward modern mathematics many prospective teachers hold at the beginning of the course.

Assuming that these assertions have some validity, the following questions might be raised:

1. During the course of one semester's work, would there be a change in student attitude?

2. Would a variation in the observation medium have a differential effect on any detected change in student attitude toward arithmetic?

3. During the course of one semester's work, would there be a change in student self-ratings of general feelings about arithmetic?
4. Would a variation of the observation medium have a differential effect on any detected change in student self-ratings of general feelings about arithmetic?

5. During the course of one semester's work, would there be a change in student expressions of self-confidence in their ability to teach "modern mathematics"?

6. Would a variation in the observation medium have a differential effect on any detected change in student expressions of self-confidence in their ability to teach "modern mathematics"?

7. During the course of one semester's work, would there be a change in student opinion relative to the ability of elementary school children to learn "modern mathematics"?

8. Would a variation in the observation medium have a differential effect on any detected change in student opinion relative to the ability of elementary school children to learn "modern mathematics"?

The second noteworthy function of the observations and related laboratory sessions in the course 67-603 is concerned with attempts to develop the pre-service teacher's ability to identify underlying mathematical misconceptions of elementary school children which result in computational errors. One of the common features of nearly all direct observations is the recording of the computational or problem-solving activities of the pupils and a subsequent analysis of these pupil responses. Very often this analysis is conducted by the demonstration teacher during a 15- or 20-minute discussion period immediately following
the observation. At other times, the in-class written work performed by the elementary school pupils during the observation is made available to the observers, and an analysis of these materials is conducted by the content-methods course instructor at the next meeting of the college class.

The aim of these activities is to encourage the pre-service teacher to look beyond the superficial aspects of a given computational error and attempt to formulate a reasonable hypothesis involving a fundamental mathematical principle or concept which is directly related to the error. This usually is not an extremely difficult assignment when the pupils' written work exhibits an error pattern, but it becomes a delicate task when individual examples of errors are the only evidence available.

If the development of this particular skill in analyzing student errors is deemed to be an important function of live observations, then the following questions might be raised concerning the utilization of filmed observations:

1. During the course of one semester's work, would there be a change in student ability to analyze computational errors?
2. Would a variation in the observation medium have a differential effect on any detected change in student ability to analyze computational errors?
3. During the course of one semester's work, would there be a change in student knowledge of arithmetic?
4. Would a variation in the observation medium have a differential effect on any detected change in student knowledge of arithmetic?
Finally, students in these classes very often express strong opinions about the need for observations in a content-methods course, thus, it should be of interest to attempt to ascertain any change in opinion due to the use of films as a replacement for live observations. The following questions might be raised:

1. During the course of one semester's work, would there be a change in student opinion of the need for live observations in a content-methods course?

2. Would a variation in the nature of the observation medium have a differential effect on any detected change in student opinion relative to the need for live observations?

3. During the course of one semester's work, would there be a change in student approval of the use of films to replace live classroom observations?

4. Would a variation in the observation medium have a differential effect on any detected change in student approval of the use of films to replace live classroom observations?

The Population and Subjects

The general population involved in this study is the set of approximately 2000 students enrolled in elementary education at Wisconsin State University—Oshkosh. The subset of this population comprising the subjects of this study were 126 junior and senior elementary education majors enrolled in six sections of Content and Methods of Elementary Arithmetic (67-603) during the fall semester of 1968 at WSU-Oshkosh. This set of subjects included both male and female enrollees. Females outnumbered males four or five to one. The subjects' ages ranged from
19 to 24 years. All but five of these students had completed at least one special methods course in science, social studies, language arts, physical education, art, music, or health education prior to their enrollment in 67-603. Every student was concurrently enrolled in one or more of these non-mathematics methods courses during the conduct of the study.

**Sampling Procedures**

At the time of registration the subjects were randomly assigned to one of six sections of *Content and Methods of Elementary Arithmetic* (67-603). This distribution process produced the following class sizes:

**TABLE 2**

<table>
<thead>
<tr>
<th>Section</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>23</td>
</tr>
<tr>
<td>II</td>
<td>23</td>
</tr>
<tr>
<td>III</td>
<td>22</td>
</tr>
<tr>
<td>IV</td>
<td>22</td>
</tr>
<tr>
<td>V</td>
<td>22</td>
</tr>
<tr>
<td>VI</td>
<td>22</td>
</tr>
</tbody>
</table>

Subsequently, the withdrawal of two students and the elimination of two students from the study, because of previous teaching experience, reduced several sections to 21 students. At the conclusion of the data gathering, the decision to equalize N in the six sections was made, so a total of four additional students were randomly eliminated from the larger sections to produce an N of 21 in each class. Although no particular effort was made to place students according to sex or year in school, the randomization procedures assigned from three to five males and from five to seven junior students to each of the sections.
The Design of the Study

The basic design of the study was a 2x3x2 factorial design involving two instructors each teaching three sections of 67-603 and using pre- and posttests to measure variables. The six sections were assigned, in pairs, to three 50-minute time periods: 8:30 A.M., 9:30 A.M., and 1:30 P.M. Three treatments were employed, two experimental and one control. Identical treatments were assigned to each pair of classes meeting at a given time, i.e., both 8:30 classes received treatment x, both 9:30 classes received treatment y, and both 1:30 classes received treatment z. This decision was based on a desire to minimize differential teacher influence by combining classes for certain activities, thus exposing all students to both teachers. This would only be possible if both sections meeting at a given time received the same treatment. The table below may help to illustrate the structural format of the study.

<table>
<thead>
<tr>
<th>Teacher (T)</th>
<th>X (8:30)</th>
<th>Y (9:30)</th>
<th>Z (1:30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Section I</td>
<td>Section III</td>
<td>Section V</td>
</tr>
<tr>
<td></td>
<td>Pre-Post</td>
<td>Pre-Post</td>
<td>Pre-Post</td>
</tr>
<tr>
<td>2</td>
<td>Section II</td>
<td>Section IV</td>
<td>Section VI</td>
</tr>
<tr>
<td></td>
<td>Pre-Post</td>
<td>Pre-Post</td>
<td>Pre-Post</td>
</tr>
</tbody>
</table>

Normally, these classes employed 12 class periods as "laboratory" sessions. For the purposes of this study, two of these sessions were
set aside for testing, and the remaining ten "laboratory" meetings of a
given class were designated to encompass one of the following treatments:

1. Treatment Eg: The members of this group had no live observ-
vations. Instead, these students viewed ten
30-minute content-methods films at the rate
of one film per week. In addition, prior to
each viewing, class members were provided
with a film guide designed to alert them to
the filmed activities they were about to see.
(See Appendix B.) The remaining 20 minutes
of each period were used to discuss questions
posed in the film guides.

2. Treatment E: The members of this group had no live observ-
vations. Instead, these students viewed the
same ten films employed in treatment Eg.
These students, however, did not have access
to the film guides prior to viewing the films.
The remaining 20 minutes of each period were
used to discuss questions about the filmed
activities.

3. Treatment C: The members of these classes comprised the
control group. They received the regular
program of "laboratory" activities. Briefly,
the ten "laboratory" sessions included six
live observations in the laboratory school,
demonstrations of the use of the overhead
projector, a lecture-demonstration by a repre-
sentative of a firm producing teaching aids
for elementary school mathematics instruction,
and two films.

These treatments were assigned at random to the three time slots, i.e.
the 8:30 classes received E, the 9:30 classes received Eg, and the 1:30
classes received C.

The MET Films

The films mentioned in the experimental treatments described
above are referred to as the MET films. In 1966, after four years of
planning, pilot programs, and the expenditure of nearly one third of a
million dollars, the National Council of Teachers of Mathematics
succeeded in producing "a series of ten color films on the system of
whole numbers, entitled 'Mathematics for Elementary Teachers' (MET)."¹

In essence, these are content-methods films because the general format of each film includes both lecture-demonstrations dealing with the content of the new mathematics programs and classroom scenes illustrating acceptable methods of developing mathematics concepts and skills at various grade levels. The titles of the films are listed below. Complete descriptions of the content of the films are available in Appendix B.

1. Beginning Number Concepts.
5. Subtraction.
6. Division.
10. The Whole Number System - Key Ideas.

Each film is approximately 30 minutes long, and the quality of the films reflects the combined efforts of the media experts, mathematicians, and mathematics educators who participated in the production of the series. Initial planning for the series began in 1962 and a set of five pilot films were produced during the summer of 1963. The results of this pilot study justified a National Science Foundation grant and this led to the ten-film series released in 1966.²

²Ibid., pp. 296-299.
This series of films is particularly attractive because the emphasis in the lecture-demonstrations is decidedly on "demonstration." A wide variety of appropriate visuals and graphics are employed, and the pace and level of instruction appear to be particularly well-suited to the intended audience, i.e., in-service and pre-service elementary school teachers. Probably the most important feature of the films pertinent to this study is the manner in which the classroom scenes are inserted at opportune times to illustrate fundamental concepts and techniques immediately after these ideas have been treated by the film teacher.

During the winter of 1968, this writer contacted several of the people who participated in the production of these films. Those contacted included Professor John Moray who plays the role of the teacher in the films. All replies indicated that up to that time the series had been employed only as an in-service training aid. None of the correspondents were aware of any evaluation studies in which the films had been used with pre-service teachers.

Unknown to these people, and certainly to this writer, a study utilizing the MET films in a course for pre-service elementary school teachers was in progress while the previously mentioned exchange of letters was taking place. The study was being conducted by Juanita Wilmoth at the University of Missouri, Columbia. A careful analysis of the Wilmoth study indicates that the investigator did not evaluate the suitability of the MET films as substitutes for observations. The course

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in which the films were employed did not include direct classroom observations. Aside from the use of the films, the only other common feature possessed by the Wilmoth study and the investigation proposed in this dissertation is that both used the same measuring instrument to examine the subjects' attitudes toward arithmetic. At this writing, the Wilmoth study is the only known "pre-service" experimental evaluation of the MET films.

The Film Guides

The film guides employed in treatment $E_g$ were constructed by this writer and were designed to prepare the student to view the films by providing a chronological sequence of the film activities. Care was taken not to provide explanations and information extending beyond the scope of the film coverage. Any "teaching" was to be the responsibility of the film, not the film guide. After a description of the filmed events had been provided, the highlights of the film were listed separately and a set of discussion questions were presented to focus attention on the main ideas illuminated by the film. Exact reproductions of the ten film guides can be found in Appendix B.

The Hypotheses

The questions raised earlier in this chapter lead directly to several hypotheses which might be postulated and tested. In order to formulate these hypotheses in very specific terms, it was necessary to precede their statement by an explanation of the structural format of the study and definitions of the treatments.

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Ibid., pp. 33-35.
The following null hypotheses occur in pairs. One member of each pair seeks to obtain information about changes occurring during the course of the study. These changes would be detected by comparing the means of the pre- and posttest for each treatment level. The second member of each pair of hypotheses seeks to ascertain possible differential effects of the experimental treatment by comparing posttest means.

The following hypotheses follow the same order in which the previous questions were stated:

1. There would be no significant difference between pre- and posttest attitudes toward arithmetic of pre-service elementary school teachers in treatment group:
   a. E: films only.
   b. Eg: films and film guides.
   c. C: control.

2. There would be no significant differences among the posttest attitudes toward arithmetic of pre-service elementary school teachers in the three treatment groups.

3. There would be no significant difference between the pre- and posttest general feelings about arithmetic of pre-service elementary school teachers in treatment group:
   a. E: films only.
   b. Eg: films and film guides.
   c. C: control.

4. There would be no significant differences among the posttest general feelings about arithmetic pre-service elementary school teachers in the three treatment groups.
5. There would be no significant difference between pre- and posttest expressions of confidence in ability to teach "modern mathematics" made by pre-service elementary school teachers in treatment group:
   a. E: films only.
   c. C: control.
6. There would be no significant differences among the posttest expressions of confidence in ability to teach "modern mathematics" made by pre-service elementary school teachers in the three treatment groups.
7. There would be no significant difference between pre- and posttest belief in the ability of elementary school children to acquire the skills and concepts of "modern mathematics" expressed by pre-service elementary school teachers in treatment group:
   a. E: films only.
   c. C: control.
8. There would be no significant differences among the posttest beliefs in the ability of elementary school children to acquire the skills and concepts of "modern mathematics" expressed by pre-service elementary school teachers in the three treatment groups.
9. There would be no significant difference between pre- and posttest computational-error-analysis ability of
pre-service elementary school teachers in treatment group:

a. E: films only.
b. Eg: films and film guides.
c. C: control.

10. There would be no significant differences among the posttest computational-error-analysis abilities of pre-service elementary school teachers in the three treatment groups.

11. There would be no significant difference between the pre- and posttest arithmetic knowledge of pre-service elementary school teachers in treatment group:

a. E: films only.
b. Eg: films and film guides.
c. C: control.

12. There would be no significant differences among the posttest arithmetic knowledge of pre-service elementary school teachers in the three treatment groups.

13. There would be no significant difference between pre- and posttest opinions of pre-service elementary school teachers in each treatment group relative to the need for live observations as a component part of a teaching-methods course. This hypothesis is postulated for treatment group:

a. E: films only.
b. Eg: films and film guides.
c. C: control.
14. There would be no significant differences among the posttest opinions of pre-service elementary school teachers in the three treatment groups concerning the need for live observations as a component part of a teaching-methods course.

15. There would be no significant difference between pre- and posttest expressions of approval by pre-service elementary school teachers in each treatment group relative to the use of films to replace live observations. This hypothesis is postulated for treatment group:
   a. E: films only.
   b. Eg: films and film guides.
   c. C: control.

16. There would be no significant differences among posttest expressions of approval by pre-service elementary school teachers in the three treatment groups relative to the use of filmed observations to replace live observations.

The Tests

Three major instruments were utilized to measure variations in the criterion variables of the study. The three main variables were: attitudes toward arithmetic, ability to analyze pupil computational errors, and the knowledge of arithmetic of the subjects of the study. The pre-service elementary school teachers also made pre-post scale-ratings on several items designed to ascertain their "feelings" about
specific aspects of the experiment. Each of these four categories will be treated individually.

**Measurement of Attitude Toward Arithmetic**

An Attitude Toward Arithmetic Scale developed by Dutton\(^5\) and refined by him after several years of experimentation,\(^6\) was employed to measure attitude changes. This scale has been used extensively to measure attitudes toward arithmetic in a variety of studies. It is a Thurstone-type scale consisting of fifteen statements, each of which expresses some measure of like or dislike for arithmetic. Each statement is assigned a numerical weight, e.g., 1.0 for dislike and 10.5 for extreme like.

An individual being evaluated checks those statements with which he agrees, and a median or average of the numerical weights of the checked statements is computed. This median score or average score is the individual's scale-score. A scale-score of 6.0 is considered to be an indication of a neutral attitude toward arithmetic. Scale-scores greater than 6.0 and those less than 6.0 are presumed to indicate attitudes toward arithmetic which are positive and negative, respectively. The scale has a reported test-retest reliability of .94.

Both "median" scale-scores and "average" scale-scores were computed for subjects in the study described in this dissertation. The pattern of results, i.e., all means and F tests of all comparisons of

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means and variances, were statistically identical, therefore only the "median" scale-scores were used in the reported data included in this study.

A replica of the Dutton Attitude Toward Arithmetic Scale is available to the reader in Appendix C. The scale and permission to use it were obtained directly from Professor Dutton.

Dutton's scale also contains items designed to elicit information related to attitudes. For example, item 16 states:

Place a circle around one number to show how you feel about arithmetic in general.

1 2 3 4 5 6 7 8 9 10 11

Dislike Like

This item was treated as a separate "instrument" in this study. This is to say, student pre-post ratings were compared to see if changes occurred, and "posttest" ratings among treatment groups were also investigated. In fact, this particular item suggested several other similarly constructed items which will be discussed later and, as a set of four items, will be called the Dutton Scale Supplement (Appendix C).

**Measurement of Ability to Analyze Computational Errors**

No device designed to measure this particular ability was found, so an instrument to detect differences in abilities of pre-service elementary school teachers to analyze computational errors was constructed by the writer. The instrument is called the Computational-Error Analysis Scale (CEAS). The scale is designed to detect differences in the abilities of pre-service elementary school teachers to recognize computational errors and make nontrivial estimates of the underlying causes of such miscalculations. Each item in the scale presents a simple computation containing an error and four hypotheses a teacher might formulate to help
pinpoint the cause of the miscalculation and define the nature and extent of remedial instruction. These hypotheses vary in level of sophistication from erroneous assumptions to recognition of specific errors to more insightful conjectures about the nature of the cause of the computational errors.

Rank orders for each set of four hypotheses associated with a given item were obtained using the ratings of twenty "experts" and Kendall's Coefficient of Concordance: $W$. The lowest ranked hypothesis in each item was assigned a value of zero (0) and the highest ranked item was assigned a value of three (3). An individual completing the scale checks the one hypothesis which he believes to be most relevant to the computational error under consideration, and, simultaneously, the one which identifies a mathematical concept he believes has the greatest probability of encompassing the actual cause of the pupil-misconception producing the computational error. The individual's item-score is the numerical weight assigned to his choice, and his scale-score is determined by summing his item-scores.

Originally 24 items were constructed and submitted to twenty "experts." Half of these experts were methods-oriented and half were content-oriented. The distinction was made on the basis of the individual's mathematical background and major teaching responsibilities. An arbitrary value of $W = .75$ was designated to be the minimum acceptable level of agreement among raters as indicated by Kendall's Coefficient of Concordance. For twenty raters, rating four items, this is an extremely high level of agreement, but the nature of the scale items seemed to indicate that such expected results were not unreasonable. Of the 24 original items, it was expected that 12 to 15 would obtain $W$'s of .75 or
greater, but, as it turned out, 20 items achieved coefficients of rater agreement greater than or equal to .75. Therefore, the final Computational-Error Analysis Scale contains 20 items.

Two Reliability Coefficients Were Determined for the CEAS Scale. A test-retest coefficient of "stability" was determined by submitting the scale to 100 students completing 67-403. This course is the highest level mathematics content course prerequisite to enrollment in 67-603, the course in which the experiment of this dissertation was conducted. The test-retest data produced a coefficient of reliability of $r = .83$.

In addition to the test-retest reliability coefficient which is primarily an indication of test "stability," a measure of "internal consistency" was also computed for the CEAS scale. The determination of this coefficient utilized the split-halves technique and the formula

$$r_{tt} = 2\left(1 - \frac{s_a^2 + s_b^2}{s_t^2}\right)$$

where $s_a$ and $s_b$ are the standard deviations of the half-tests and $s_t$ is the standard deviation of the complete test. This formula is recommended by Cronbach\(^7\) as a "better estimate" of the true value of the coefficient than that produced by the often employed Spearman-Brown formula. The very popular "Kuder-Richardson Formulae 20 and 21" frequently used to ascertain internal consistency are inappropriate for use with the CEAS scale because the items of the scale are not scored "right or wrong."

A "right or wrong" scoring technique is a necessary condition for the

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utilization of KR20 and/or KR21. The "internal consistency" computations using Cronbach's recommended formula produced a value of $r = .74$.

The two values obtained, $r = .83$ (stability) and $r = .74$ (internal consistency) are both statistically significant from zero. Edwards provides a table which indicates that for tests of significance from zero, with 18 degrees of freedom, a correlation coefficient of .561 is statistically significant at the .005 level. Since both values are considerably greater than .561, it would seem that the values obtained are quite acceptable.

One other comment might be made. As reported earlier in the review of the literature, a number of investigators constructed measuring instruments and the reported reliability coefficients for these tests ranged from .60 to .80, so it would appear that the reliability coefficients obtained for the CEAS scale compare favorably with similar values obtained by other "non-commercial" test builders.

The Validity of the CEAS Scale Depends Primarily on Two Factors Inherent in Its Construction. The first of these factors has to do with the validity of the computational problems utilized in the scale items. Every item in the scale contains a computational error which is either an actual error made by an elementary school child, or it is an item which is a reasonable facsimile of one. In addition, the postulated hypotheses found in each scale item are, in most instances, "reasons" for the error proposed by pre-service elementary school teachers.

The second factor which might serve to describe the validity of the CEAS scale is related to the fact that the tentative hypotheses

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included in each scale item were rank-ordered by a panel of twenty "experts." All but one of these "experts" teach arithmetic content-methods courses, supervise student teachers, or act as cooperating teachers. Several have had experience with all three instructional activities.

Due to the make-up of the panel, the rank-orderings of the sets of hypotheses found in each scale item reflect the combined opinions of the very people who are most likely to judge a given student's ability to analyze computational errors in real-life situations, e.g., while student teaching. Thus, when a student selects an hypothesis which has been assigned a numerical level of sophistication by a panel of this complexion, he is submitting an example of his ability to analyze computational errors, albeit ex post facto, to evaluation by a group of people which includes those persons most apt to be in a position to judge his actual behavior along these lines.

The CEAS scale, then, is valid to the degree that the panel of experts is actually representative of the total population of those persons who might judge the student's ability to analyze computational errors and to the degree that agreement among the panel members approaches consensus on the rank-ordering of the hypotheses. The careful selection of the panel and the stringent requirement for a high level of agreement on rank-ordering, i.e., $W \geq .75$, were designed to insure that both of these necessary conditions would be at optimum levels.
Measurement of General Mathematics Achievement

The California Survey of Mathematics Achievement, Advanced Grades 9-12, Form 1, was used to measure arithmetic achievement and computational ability. The authors state that "the two phases of achievement in arithmetic-reasoning and skill in the fundamental processes" are both treated thoroughly by the test. The test is not a "modern mathematics" test. It was selected primarily because it emphasized computation while it provided a survey of arithmetic achievement. If the test authors' assessment relative to "reasoning" and "fundamental process" is correct, then the test could serve as a control for the Computational-Error Analysis Scale which logically should be closely related to both of these "phases of arithmetic achievement." The reported reliability of the test, computed with Kuder-Richardson Formula 21, is .90.

Dutton Scale Supplement

Item number 16 on the Dutton Attitude Toward Arithmetic Scale was used as a model for the four items listed below. Each item requires the student to rate his "feelings" about some aspect of the study. The student indicates his "feelings" by circling one of the numerals in an ordered list from 1 to 11. The numeral 1 represents the extreme negative and 11 represents the extreme positive reaction to the premise of each statement.

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10Ibid., p. 3.

11Ibid., p. 4.
1. Place a circle around one number to show how you feel about the prospect of teaching elementary school arithmetic.

   1  2  3  4  5  6  7  8  9  10  11

   Apprehensive          Confident

2. Place a circle around one number to show how you feel about the likelihood that elementary school children will be able to learn "modern mathematics."

   1  2  3  4  5  6  7  8  9  10  11

   Unlikely               Likely

3. Place a circle around one number to show how you feel about the importance of including live observations of student-learning activities as a component part of a teaching-methods course.

   1  2  3  4  5  6  7  8  9  10  11

   Nonessential           Essential

4. Place a circle around one number to show how you feel about the use of the NCTM films to replace live classroom observations.

   1  2  3  4  5  6  7  8  9  10  11

   Disapprove              Approve

Each item was analyzed as an individual "test" by considering all student self-ratings on a given item as a set of "test" scores. Pre- and posttest ratings provided an opportunity to investigate changes in student reactions to very specific phenomena.

The Conduct of the Study

Probably the best way to analyze the sequence of events which comprise the "conduct of the study" is to investigate four chronologically defined subdivisions, i.e., the preliminary phase, the pretest phase, the treatment phase, and the posttest phase. The preliminary phase encompasses those preparatory activities required prior to the first student involvement. The pretest phase includes the initial data collecting activities. The treatment phase is a description of the manner in which
the experimental treatments were implemented, and the posttest phase includes a short description of the final data collecting.

Preliminary Phase

The films used in the study were rented from the University of Wisconsin Bureau of Audio-Visual Instruction (BAVI), Madison, Wisconsin. Films ordered from BAVI are available to the renter for a full week. These films were scheduled at the rate of one film per week beginning with the third week of the semester (September 23-27). No film or laboratory session was scheduled during Thanksgiving week. All films arrived and were viewed according to schedule.

The complete set of films was obtained six weeks prior to the beginning of the semester, and during that period of time the film guides were prepared. During the week prior to the opening of school, the final arrangements were made to administer the pretests.

Pretest Phase

The pretests were administered on two different days. The Computational-Error Analysis Scale and Dutton Attitude Toward Arithmetic Scale were administered during registration week on September 4, 1968. No time limit was specified for completing the scales, although the completion-time for each student was recorded. The range of these completion-times was 25 to 40 minutes.

Normally, the first meeting of each class is devoted to providing an overview of the course and collecting information about the students and their programs. On the first day of the semester, September 9, the sections assigned the same class hour met in combined groups. During the description of the course, the students were told that some of the sections would have live observations in the campus school while others
would have filmed observations. None of the students knew which classes were scheduled for films until the first films were shown during the third week of the semester. This point is significant because a pretest reaction to item four of the Dutton Scale Supplement concerning the students' feelings about the utilization of filmed observations was desired.

On Wednesday, September 11, the Survey of Arithmetic and the Dutton Scale Supplement were administered.

Control measures were to include Composite American College Test (ACT) scores and grade-point averages of the prerequisite mathematics content courses 67-203 and 67-403. As soon as student enrollments were verified and the ACT scores and previous mathematics course grades of the subjects had been obtained, a 1x6 analysis of variance was computed for each of the two measures. The results of these computations are indicated in the tables below.

**TABLE 4**

ANALYSIS OF VARIANCE FOR GRADE-POINT AVERAGES IN PREREQUISITE MATHEMATICS COURSES 67-203 AND 67-403

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>4.5238</td>
<td>5</td>
<td>.90</td>
<td>1.77*</td>
</tr>
<tr>
<td>Within</td>
<td>61.4632</td>
<td>120</td>
<td>.51</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>65.9870</td>
<td>125</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Nonsignificant, .05 level*
TABLE 5

ANALYSIS OF VARIANCE FOR COMPOSITE AMERICAN COLLEGE TEST SCORES

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>277.4920</td>
<td>5</td>
<td>55.50</td>
<td>1.29*</td>
</tr>
<tr>
<td>Within</td>
<td>5179.8092</td>
<td>120</td>
<td>43.17</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5457.3012</td>
<td>125</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Nonsignificant, .05 level

All tests of null hypotheses in this study were made at the .05 level of significance, and all tests of homogeneity of variances employed the $F_{max}$ test. The $F_{max}$ test for homogeneity of variances proposed by H. O. Hartley and described by Winer\textsuperscript{12} is a technique which compares the maximum and minimum variances derived from a set of $K$ treatments having equal N's. Special $F_{max}$ tables are required when using this statistic. For $df(6,20)$, .05 level, the critical value of the $F_{max}$ statistic is $F_{max} = 3.76$. For these two sets of data, $F_{max}$ values of 2.00 for Grade-Point Averages and 1.36 for Composite ACT Scores were obtained. Each of these numbers is less than the critical value 3.76, therefore, the null hypothesis of homogeneity of variances for the six classes is retained in each instance.

The critical value for the analysis of variance F's, $df(5,120)$, is $F = 2.29$. Therefore, the Grade-Point Average $F = 1.77$ and the Composite ACT Score $F = 1.29$ are both nonsignificant at the .05 level. The null hypothesis relative to the means, i.e., $m_1 = m_2 = \ldots = m_6$, is

retained for each of the two sets of data. These results lead to the conclusion that, for each variable measured, the six classes are presumed to be samples of the same population.

In one sense, the pretest for each instrument used in the pre-post statistical design can be interpreted as a "control" measure. Similar 1x6 analyses of variance were computed for the pretests of the Survey of Arithmetic, the Computational-Error Analysis Scale, Item 16 on the Dutton Scale, and the four items of the Dutton Scale Supplement. The results of these computations indicated that, for each instrument, score variances were statistically homogeneous and mean differences were not statistically significant. The data from which these results were obtained are reported in Appendix A.

**Treatment Phase**

The treatments: E (films only), Eg (films and film guides), and C (control), had previously been randomly assigned to the time periods 8:30 A.M., 9:30 A.M., and 1:30 P.M., respectively. The original intention was to designate Friday as "laboratory day" in all six sections with the film guides handed out to the 9:30 classes at the Wednesday meeting. This plan, however, provided opportunities for the members of the films-only groups to gain access to film guides during the intervening 48 hours. To eliminate this possibility, the following scheme was devised. Laboratory films were shown in the films-only classes at 8:30 on Wednesdays. Film guides were issued to the film-guide groups at 9:30 on Wednesdays and these classes viewed the films on Fridays. This prevented the films-only group from obtaining the film guides prior to viewing the films. At the same time, the film-guide groups had the guides 48 hours
before viewing the films. This procedure was employed throughout the study.

Each Laboratory Session of the Four Experimental Classes Began by Viewing One of the MET Films. Each of these films was approximately 30 minutes in length. The remaining 20 minutes of each class period were used for discussion. Generally, the discussion questions included in the film guides defined the scope of the topics treated in the film-guide classes, although any pertinent questions raised by students were carefully considered. In the films-only classes, the discussions centered almost entirely on student comments and questions. Occasionally, questions from the film guides were introduced by the teacher.

Classes meeting at 8:30 (and 9:30) were combined for film-viewing purposes. Initially, the follow-up discussions also involved the combined classes, but the double-sized group and the relatively short 20-minute discussion period did not permit all interested students to participate fully. Therefore, subsequent laboratory sessions maintained the combined-class film viewing, but the "visiting" group returned to its regular classroom next door for the post-viewing discussion.

The Laboratory Sessions of the Control Groups had a More Varied Format than the Experimental Classes. During the course of the semester each class, meeting as a group, participated in six live observations in the campus laboratory school. Section V visited the first, second, third, fifth, sixth, and seventh grades, while Section VI visited the first, second, fourth, fifth, sixth, and seventh grades.

Prior to the first observation, Flanders' System of Interaction Analysis was described by each instructor, and an Observation Outline (Appendix D) incorporating the categories devised by Flanders was
introduced and explained. Following the first live observation, the outline was employed to analyze the observed teaching-learning activities. Subsequently, each student selected three of the remaining five observations for which he prepared a two- or three-page written "observation report" structured along the lines of the Observation Outline.

The remaining four laboratory sessions provided for the control groups included a demonstration of the uses of the overhead projector, a lecture-demonstration on new teaching aids for arithmetic teachers, and the viewing of two films normally employed as laboratory sessions in the course 67-603.

An overhead projector is a remarkably versatile device for illustrating simple mathematical-set configurations and relationships. Ordinary opaque objects such as paper clips, pencils, coins, and tacks can be grouped, joined, paired, or separated on the surface plate of the projector to reflect a variety of black-and-white set formations on the screen. Translucent plastic figures can be used to add color to the visual patterns observed. Various techniques of this type, to be used in conjunction with the overhead projector, were illustrated during this laboratory session.

Another laboratory session consisted of a 50-minute demonstration by a representative of a commercial firm. He exhibited and demonstrated a variety of aids suitable for teaching elementary school arithmetic. Mechanical representations of number sentences, drill tapes, magnetic boards, and Cuisenaire rods are representative examples of the devices described in this demonstration.

The ninth and tenth laboratory sessions were devoted to viewing and discussion two commercially produced films. The first film, The
Unending Search for Excellence, depicted the educative utilization of the tape recorders, overhead projectors, television, and programmed instruction. The second film, Mathematics for Tomorrow, described the need for a reorganization of the mathematics curriculum and emphasized the need for employing the discovery approach in the teaching of mathematics.

Every Attempt Was Made to Provide Uniform Learning Experiences in the "Non-Laboratory" Phase of All Six Sections. The two teachers planned most activities together, and twelve combined-class meetings were organized. Each teacher taught four of these combined classes, and both teachers participated in the instructional activities of the other four joint meetings. All assigned problems, readings, and worksheets utilized in these sessions were discussed, evaluated, and used by common consent. Many materials for use in the classes were developed cooperatively both before and during the experiment.

Posttest Phase

Posttesting took place on December 18, 1968 and January 8, 1969. The instruments used to measure the initial status of the subjects were also used as posttests. The Dutton Attitude Toward Arithmetic Scale, the Dutton Scale Supplement, and the Computational-Error Analysis Scale were administered on December 18, 1968 while the Survey of Arithmetic was administered on January 8, 1969.

During the interval between pre- and posttesting, two individuals withdrew from the course, and two students who were experienced teachers without baccalaureate degrees were eliminated from the study. This resulted in sections having unequal N's of 23, 22, 21, 21, 22, 21. After consulting with several statisticians at the University of Kansas and at Wisconsin State University-Oshkosh, this writer was advised to equalize
the number of subjects in each cell by randomly removing subjects from cells until each one contained 21 students. A table of random digits was employed to remove two subjects from section I, one each from sections II and V.

**Limitations of the Study**

This study was conducted at Wisconsin State University--Oshkosh. A rather extensive description of the institution and its student population was provided in Chapter II in order to increase the possibility of generalizing any significant results of this study to schools having characteristics and student populations similar to those of WSU-Oshkosh. Any findings concerning the utilization of the MET-film series, however, must be considered to be the result of its use under the prescribed conditions of the experiment. Due caution should be exercised when attempts are made to apply generalizations engendered by this study to other institutional situations.

One other possible limiting factor concerns the vocabulary employed in the items of the Computational-Error Analysis Scale. Attempts were made to utilize vocabulary which would be meaningful to nearly all students having had some work in "modern mathematics," but it is possible that some terms may not be a part of the working vocabulary of all pre-service elementary school teachers.

**Description of the Statistical Analyses**

The statistical design of this study is a TxExP factorial design with repeated measures, i.e., pre- and posttests, on factor P. This
design is described in detail by Winer\(^{13}\) in his book *Statistical Principles In Experimental Design*. Winer is one of the few authors to treat this particular technique thoroughly and provide computational formulae. The symbols \(T, E, P\) were selected to identify the main factors in the statistical analyses: \(T\) identifies the two teachers, \(T_1\) and \(T_2\); \(E\) identifies the three treatments, \(E\) (films only), \(E_g\) (films and film guides), and \(C\) (control); and \(P\) identifies the pre- and posttest, \(P_1\) and \(P_2\). The design, then, is fundamentally a 2-by-3-by-2 multivariate design.

This type of design has been recommended by various authorities involved in media research. Lesser and Schueler, for example, reviewed a variety of media research projects conducted prior to 1966 and made a number of recommendations concerning future research in this area. In regard to experimental design, they said:

> Multivariate designs should be used wherever possible to determine not only the influence of the main treatment effects (e.g., observational conditions, instructor differences, differences among college students in general scholastic ability, semester differences, etc.) but also the interactions among these independent variables.\(^{14}\)

These men also recommended random assignment of subjects and pre-post measures of change.\(^{15}\) All three of these recommendations by Lesser and Schueler are incorporated in the statistical design of this study.

Summary tables for this kind of analysis of variance yield \(F\) values for the effects of \(T, E,\) and \(T \times E\) which utilize an error term

\(^{13}\)Winer. *op. cit.*, pp. 337-344.

\(^{14}\)Gerald S. Losser and Herbert Schueler. "New Media Research in Teacher Education." *AV Communication Review*, 14 (Fall, 1966) 337.

\(^{15}\)Ibid., p. 337.
identified as SS_{subjects within groups}, "a source of variation which is a measure of the extent to which the mean of a subject differs from the mean of the group in which the subject is located."\textsuperscript{16} The F values which indicate the effects of P, TxP, ExP, and TxExP are ascertained utilizing the error term SS_{PxSubjects within groups} which is the difference between the SS within cell variation and the SS_{subjects within groups} variation.

Tests for homogeneity of error variances in this study were made by subdividing each error term, i.e., SS_{subjects within groups} and SS_{PxSubjects within groups}, to provide the corresponding variance for each cell and testing these two sets of six variances with the $F_{max}$ statistic. Similar tests for homogeneity of variance were made for pooling purposes.

The summary tables indicate significant main effects or interactions and thereby identify those points at which further statistical investigations should be made. Each significant F in the summary table is an indication that appropriate tests should be utilized to check differences between or among cell means.

\textsuperscript{16}Winer. \textit{op. cit.}, p. 339.
CHAPTER IV

ANALYSIS OF THE DATA

Method of Reporting the Data

Basically, this chapter includes eight subdivisions designed to facilitate the analysis of the data obtained via the testing procedures embodied in the design of the study. Each subsection exhibits the same basic format. First, one pair of related hypotheses is stated for easy reference and the test or self-rating item relevant to the testing of the hypotheses is identified.

Following the identification of the hypotheses and the evaluation instrument, a multivariate analysis of variance summary table for the specified instrument is presented. Significant F values in this summary table direct the attention of the investigator to specific subtests needed to test the hypotheses directly. Nonsignificant F values in this particular summary table indicate that the effect of the variable or interaction of variables under consideration is negligible and does not warrant further investigation.

The first null hypothesis of each pair actually asserts three things, i.e., no significant difference between pretest and posttest means for each of the three treatment groups. Therefore, a second summary table is provided which reveals the pretest and posttest means for each of the treatment groups and the results of F tests for significant pro-post mean differences. These F values enable the investigator to
make specific statements relative to the retention or rejection of the null hypotheses dealing with possible pre-post mean differences.

The other member of each pair of null hypotheses focuses attention on possible posttest mean differences among the three treatment groups. The reported $F_{\text{post}}$ value indicates whether or not significant differences among posttest treatment-group means exist. The $F_{\text{post}}$ value is analogous to the $F$ value resulting from an ordinary analysis of variance involving three treatment groups. (The $F_{\text{pre}}$ value is computed in a similar manner and is reported to establish the initial status of the treatment groups at the beginning of the experiment.) If the $F_{\text{post}}$ value is significant, further tests are employed to investigate possible posttest mean differences between paired treatment groups. Although these particular tests are $F$ tests employing basic data from the multivariate design, they perform the same function as ordinary $t$-tests.

In summary, each of the eight subdivisions in the following section includes: (1) statements of the related pairs of null hypotheses, (2) the identification of the relevant measurement instrument, (3) a multivariate analysis of variance summary table, and (4) a summary table of data required to make specific decisions about the retention or rejection of null hypotheses concerning pre- and posttest mean differences of the treatment groups. Occasionally, significant $F_{\text{post}}$ values indicate that additional data tables are required to investigate differences among the posttest means. These tables are provided whenever they are appropriate. The remaining portion of each of the subsections consists of a brief interpretation of the tabulated data.
The Tests of the Hypotheses

The eight subdivisions described by the method of reporting the data are contained in this section.

Hypotheses One and Two

1. There is no significant difference between pre- and posttest attitudes toward arithmetic of pre-service elementary school teachers in treatment group:
   a. E: films only.
   b. Eg: films and film guides.
   c. C: control.

2. There are no significant differences among the posttest attitudes toward arithmetic of pre-service elementary school teachers in the three treatment groups.

The Dutton Attitude Toward Arithmetic Scale was employed to measure this criterion variable. The results of the multivariate analysis of variance of the scores obtained on this scale are reported in Table 6.

TABLE 6

MULTIVARIATE ANALYSIS OF VARIANCE FOR THE DUTTON ATTITUDE TOWARD ARITHMETIC SCALE

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Critical F (.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>627.8260</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T (teacher)</td>
<td>.2572</td>
<td>1</td>
<td>.26</td>
<td>.05</td>
<td>3.92</td>
</tr>
<tr>
<td>E (experimental)</td>
<td>.6717</td>
<td>2</td>
<td>.34</td>
<td>.06</td>
<td>3.07</td>
</tr>
<tr>
<td>TxE</td>
<td>.7167</td>
<td>2</td>
<td>.36</td>
<td>.07</td>
<td>3.07</td>
</tr>
<tr>
<td>Subj. W. Groups</td>
<td>626.1804</td>
<td>120</td>
<td>5.22</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The results reported in Table 6 show that of the three main effects—teachers, experimental treatment, and pre-post testing—only \( P \) (pre-post testing) produced a significant \( F \) value. All interaction \( F \) values are nonsignificant. The lack of significant interactions indicates that there are negligible differential effects due to the utilization of two different teachers or to the application of treatments. The significant value for \( P \), i.e., \( F = 29.72 \), signifies that at least one treatment group experienced a significant change from pretest to posttest. Table 7, below, provides specific pre-post testing data about each treatment group.

**TABLE 7**

COMPARISONS OF TREATMENT-GROUP MEANS FOR THE DUTTON ATTITUDE TOWARD ARITHMETIC SCALE

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cell Means</th>
<th>Critical F (.05)</th>
<th>Null Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>( F )</td>
</tr>
<tr>
<td>E: films-only</td>
<td>5.67</td>
<td>6.31</td>
<td>11.81</td>
</tr>
<tr>
<td>E: film-guide</td>
<td>5.69</td>
<td>6.19</td>
<td>7.16</td>
</tr>
<tr>
<td>C: control</td>
<td>5.75</td>
<td>6.38</td>
<td>11.08</td>
</tr>
</tbody>
</table>

\[ \text{df}(1,120) \]

\[ F_{\text{pre}} = .03 \quad 3.04 \]
\[ F_{\text{post}} = .13 \quad 3.04 \]

Treatment Group N = 42

\[ \text{df}(2,240) \]
The data in Table 7 reveal that each treatment group experienced a statistically significant positive change in attitude toward arithmetic as measured by the Dutton Scale, because the F values 11.81, 7.16, and 11.08 are all greater than the critical \( F_{0.05} \) value of 3.92. Therefore, each of the three null hypotheses emanating from "Hypothesis 1" are rejected. On the other hand, since \( F_{post} = 0.13 \) is less than the critical value of \( F = 3.04 \), the second null hypothesis is retained. That is to say, there appear to be no significant differences among the posttest treatment means. The \( F_{pre} \) value of 0.03 indicates that the initial status of the three treatment groups was essentially the same.

**Hypotheses Three and Four**

3. There is no significant difference between pre- and posttest general feelings about arithmetic of pre-service elementary school teachers in treatment groups:
   a. \( E_1 \): films only.
   b. \( E_g \): films and film guides.
   c. \( C \): control.

4. There are no significant differences among the posttest general feelings about arithmetic of pre-service elementary school teachers in the three treatment groups.

**Student reactions to Item 16 on the Dutton Attitude Toward Arithmetic Scale** were used to test these hypotheses. A restatement of Item 16 follows:

Place a circle around one number to show how you feel about arithmetic in general.

1  2  3  4  5  6  7  8  9  10  11

**Dislike**  **Like**
The multivariate analysis of variance of the student responses to this particular item will be found in Table 8.

### TABLE 8

**MULTIVARIATE ANALYSIS OF VARIANCE OF STUDENT RESPONSES TO ITEM SIXTEEN ON THE DUTTON ATTITUDE TOWARD ARITHMETIC SCALE**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Critical F (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>942.6508</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T (teacher)</td>
<td>4.0634</td>
<td>1</td>
<td>4.06</td>
<td>.52</td>
<td>3.92</td>
</tr>
<tr>
<td>E (experimental)</td>
<td>6.1269</td>
<td>2</td>
<td>3.06</td>
<td>.39</td>
<td>3.07</td>
</tr>
<tr>
<td>TxE</td>
<td>1.1747</td>
<td>2</td>
<td>.59</td>
<td>.08</td>
<td>3.07</td>
</tr>
<tr>
<td>Subj. W. Groups</td>
<td>931.2858</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>113.0000</td>
<td>126</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P = PrexPost</td>
<td>22.9206</td>
<td>1</td>
<td>22.92</td>
<td>31.24</td>
<td>3.92</td>
</tr>
<tr>
<td>TxP</td>
<td>.2541</td>
<td>1</td>
<td>.25</td>
<td>.35</td>
<td>3.92</td>
</tr>
<tr>
<td>ExP</td>
<td>1.5556</td>
<td>2</td>
<td>.78</td>
<td>1.06</td>
<td>3.07</td>
</tr>
<tr>
<td>TxExP</td>
<td>.2221</td>
<td>2</td>
<td>.11</td>
<td>.15</td>
<td>3.07</td>
</tr>
<tr>
<td>PxSubj. W. Groups</td>
<td>88.0476</td>
<td>120</td>
<td></td>
<td>.73</td>
<td></td>
</tr>
</tbody>
</table>

The data in Table 8 indicate that the main effect P (pre-post testing) produced a significant F value of 31.24. All other main effects and interactions yielded nonsignificant F values indicating that the influence exerted by these particular variables were negligible. The statistically significant F value for the main effect P implies that at least one treatment group experienced a significant mean change from pre-test to posttest. In order to pursue this line of inquiry, the results of the analyses of the individual treatment-group data are reported in Table 9, page 113.
### TABLE 9

COMPARISONS OF TREATMENT-GROUP MEANS FOR ITEM SIXTEEN ON THE DUTTON ATTITUDE TOWARD ARITHMETIC SCALE

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cell Means</th>
<th>Critical F (.05)</th>
<th>Null Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td>E: films-only</td>
<td>7.07</td>
<td>7.64</td>
<td>9.35</td>
</tr>
<tr>
<td>Eg: film-guide</td>
<td>6.76</td>
<td>7.19</td>
<td>5.25</td>
</tr>
<tr>
<td>C: control</td>
<td>6.74</td>
<td>7.55</td>
<td>18.76</td>
</tr>
</tbody>
</table>

DF(1,120)

F<sub>pre</sub> = .34 3.04  
F<sub>post</sub> = .56 3.04

Reject 3a  
Reject 3b  
Reject 3c

Treatment Group N = 42

DF(2,240)

Data in Table 9 show that statistically significant differences between pretest and posttest means exist for each of the three treatment groups. In each instance, the direction of the change was positive in the sense that higher mean scores on the posttest revealed a greater "like" for arithmetic at the end of the experiment that at the beginning. The significant F scores of 9.35, 5.25, and 18.76 lead to the rejection of the null hypotheses 3a, 3b, and 3c.

The F<sub>pre</sub> = .34 is nonsignificant indicating that any apparent differences among pretest treatment-group means are not statistically significant. The F<sub>post</sub> value of .56 is also nonsignificant and indicates that the null hypothesis, Hypothesis 4, should be retained.

Hypotheses Five and Six

5. There is no significant difference between pre- and posttest expressions of confidence in ability to teach "modern mathematics" made by pre-service elementary school teachers in treatment group.
a. E: films only.

b. E: films and film guides.

c. C: control.

6. There are no significant differences among the posttest expressions of confidence in ability to teach "modern mathematics" made by pre-service elementary school teachers in the three treatment groups.

The instrument employed to test these hypotheses was the Dutton Scale Supplement Item 1:

Place a circle around one number to show how you feel about the prospect of teaching elementary school arithmetic.

1 2 3 4 5 6 7 8 9 10 11
Apprehensive Confident

The results of the multivariate analysis of the student pre- and posttest responses to this particular item are reported in Table 10 below.

TABLE 10

MULTIVARIATE ANALYSIS OF VARIANCE OF STUDENT RESPONSES TO ITEM ONE OF THE DUTTON SCALE SUPPLEMENT

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Critical F (.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>573.4286</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T (teacher)</td>
<td>.3968</td>
<td>1</td>
<td>.40</td>
<td>.08</td>
<td>3.92</td>
</tr>
<tr>
<td>E (experimental)</td>
<td>4.7857</td>
<td>2</td>
<td>2.39</td>
<td>.51</td>
<td>3.07</td>
</tr>
<tr>
<td>TxE</td>
<td>.3413</td>
<td>2</td>
<td>.17</td>
<td>.04</td>
<td>3.07</td>
</tr>
<tr>
<td>Subj. W. Groups</td>
<td>567.9048</td>
<td>120</td>
<td>4.73</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The data in Table 10 reveal a highly significant F value for the main effect P and nonsignificant F's for all other main effects and interactions of variables. The F values 1.62 and 1.47 for the Txp and ExP interactions, respectively, indicate that the use of two teachers and the application of the treatments had a noticeable, but not statistically significant, effect on the pre-post pattern of change. The subsequent comparisons of separate treatment-group pre- and posttest means suggested by the F = 281.96 for the main effect P are indicated below in Table 11.

### TABLE 11

**COMparisons of Treatment-Group Means for Item One of the Dutton Scale Supplement**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Cell Means</th>
<th>Critical F (.05)</th>
<th>Null Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td>E: films-only</td>
<td>5.67</td>
<td>8.02</td>
<td>118.95</td>
</tr>
<tr>
<td>E: film-guide</td>
<td>5.55</td>
<td>7.64</td>
<td>93.99</td>
</tr>
<tr>
<td>C: control</td>
<td>6.00</td>
<td>7.83</td>
<td>71.96</td>
</tr>
</tbody>
</table>

F\(\text{pre} = .81\) = 3.04

F\(\text{post} = .52\) = 3.04

Treatment Group N = 42  

df(1,120)  

Retain 4  

df(2,240)
An inspection of Table 11 discloses considerable increases in the mean scores of each treatment group from pretesting to posttesting. The F values reported in the table show that these increases are highly significant and reflect dramatic increases in the students' asserted self confidence with respect to the teaching of elementary school mathematics. It follows that the null hypotheses 5a, 5b, and 5c are rejected. Since the \( F_{\text{post}} = 0.52 \) is nonsignificant, the null hypothesis of no significant differences among posttest treatment-group means is retained.

Hypotheses Seven and Eight

7. There is no significant difference between pre- and posttest belief in the ability of elementary school children to acquire the skills and concepts of "modern mathematics" expressed by pre-service elementary school teachers in treatment group:
   a. \( E_i \): films only.
   b. \( E_g \): films and film guides.
   c. \( C \): control.

8. There are no significant differences among the posttest beliefs in the ability of elementary school children to acquire the skills and concepts of "modern mathematics" expressed by pre-service elementary school teachers in the three treatment groups.

The criterion measurement instrument employed to test these hypotheses was the Dutton Scale Supplement Item 2:

Place a circle around one number to show how you feel about the likelihood that elementary school children will be able to learn "modern mathematics."

Unlikely 1 2 3 4 5 6 7 8 9 10 11 Likely
TABLE 12

MULTIVARIATE ANALYSIS OF VARIANCE OF STUDENT RESPONSES TO ITEM TWO OF THE DUTTON SCALE SUPPLEMENT

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Critical F (.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>554.8572</td>
<td>125</td>
<td>1.92</td>
<td>.42</td>
<td>3.92</td>
</tr>
<tr>
<td>T (teacher)</td>
<td>1.9206</td>
<td>1</td>
<td>1.92</td>
<td>.42</td>
<td>3.92</td>
</tr>
<tr>
<td>E (experimental)</td>
<td>2.2143</td>
<td>2</td>
<td>1.11</td>
<td>.24</td>
<td>3.07</td>
</tr>
<tr>
<td>TxE</td>
<td>.2937</td>
<td>2</td>
<td>.15</td>
<td>.03</td>
<td>3.07</td>
</tr>
<tr>
<td>Subj. W. Groups</td>
<td>550.4286</td>
<td>120</td>
<td>4.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td>640.0000</td>
<td>126</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P = PrexPost</td>
<td>520.0159</td>
<td>1</td>
<td>520.02</td>
<td>528.19</td>
<td>3.92</td>
</tr>
<tr>
<td>TxP</td>
<td>1.0159</td>
<td>1</td>
<td>1.02</td>
<td>1.02</td>
<td>3.92</td>
</tr>
<tr>
<td>ExP</td>
<td>.0555</td>
<td>2</td>
<td>.03</td>
<td>.03</td>
<td>3.07</td>
</tr>
<tr>
<td>TxExP</td>
<td>.7698</td>
<td>2</td>
<td>.38</td>
<td>.39</td>
<td>3.07</td>
</tr>
<tr>
<td>PxSubj. W. Groups</td>
<td>118.1429</td>
<td>120</td>
<td>.98</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An inspection of Table 12 reveals that the only main effect to produce a significant F value is P (pre-post testing) and that this particular value is highly significant. The results of further analysis of this effect are reported in Table 13.
TABLE 13
COMPARISONS OF TREATMENT-GROUP MEANS FOR ITEM TWO OF THE DUTTON SCALE SUPPLEMENT

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cell Means</th>
<th>F</th>
<th>Critical F (.05)</th>
<th>Null Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E: films-only</td>
<td>6.31</td>
<td>9.21</td>
<td>179.98</td>
<td>3.92</td>
</tr>
<tr>
<td>Eg: film-guide</td>
<td>6.29</td>
<td>9.17</td>
<td>177.04</td>
<td>3.92</td>
</tr>
<tr>
<td>C: control</td>
<td>6.52</td>
<td>9.36</td>
<td>171.24</td>
<td>3.92</td>
</tr>
<tr>
<td></td>
<td>df(1,120)</td>
<td>F = .26</td>
<td>3.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F post = .15</td>
<td>3.04</td>
<td></td>
</tr>
</tbody>
</table>

Treatment Group N = 42 df(2,240)

The information in Table 13 describes a pattern quite similar to the previous analyses of treatment-group means. Each of the three groups exhibits a marked positive change in mean-scores from pretest to posttest, a change which is statistically significant for each of the three groups. This information is sufficient to reject the null hypotheses 7a, 7b, and 7c. In addition, the nonsignificant value $F_{post} = .15$ denotes the lack of statistically significant posttest mean differences. The evidence provided in Table 13 indicates that at the end of the study members of each treatment group held substantially stronger beliefs in the ability of youngsters to learn "modern mathematics" than they held at the beginning of the investigation.

Hypotheses Nine and Ten

9. There is no significant difference between pre- and posttest computational-error-analysis ability of preservice elementary school teachers in treatment group;
a. E: films only.
b. Eg: films and film guides.
c. C: control

10. There are no significant differences among the posttest computational-error-analysis abilities of pre-service elementary school teachers in the three treatment groups.

The criterion measurement instrument employed to test these hypotheses was the Computational-Error Analysis Scale. The results of the multivariate analysis of variance of the scores obtained on this instrument are reported in Table 14, below.

TABLE 14

MULTIVARIATE ANALYSIS OF VARIANCE OF STUDENT SCORES ON THE COMPUTATIONAL-ERROR ANALYSIS SCALE

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Critical F (.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>6,668.0199</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T (teacher)</td>
<td>12.0040</td>
<td>1</td>
<td>12.00</td>
<td>.22</td>
<td>3.92</td>
</tr>
<tr>
<td>E (experimental)</td>
<td>150.8889</td>
<td>2</td>
<td>75.44</td>
<td>1.39</td>
<td>3.07</td>
</tr>
<tr>
<td>TxE</td>
<td>19.0793</td>
<td>2</td>
<td>9.54</td>
<td>.18</td>
<td>3.07</td>
</tr>
<tr>
<td>Subj. W. Groups</td>
<td>6,486.0477</td>
<td>120</td>
<td>54.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Within Subjects

| P = PrexPost        | 3,756.8611     | 1  | 3,756.86    | 245.54| 3.92            |
| TnP                 | 6.6706         | 1  | 6.67        | .44 | 3.92            |
| Exp                 | 373.7460       | 2  | 186.87      | 12.21| 3.07            |
| TxExP               | 1.1747         | 2  | .59         | .04 | 3.07            |
| PxSubj. W. Groups   | 1,836.0476     | 120| 15.30       |   |                 |

The data reported in Table 14 reveal a highly significant F value for P (pre-post testing) which indicates that differences exist
between pretest and posttest scores. In addition, the ExP interaction effect yielded an F of 12.21 which is also statistically significant. The symbol ExP identifies an interaction between the experimental treatment and the pre-post change. Thus, in combination, the statistically significant values for P and ExP indicate that a change from pretest to posttest occurred and that the experimental treatment played a significant role in determining the pattern of that pre-post change. Information regarding the nature of this pattern of change is provided in Table 15.

**TABLE 15**

**COMPARISONS OF TREATMENT-GROUP MEANS FOR THE COMPUTATIONAL-ERROR ANALYSIS SCALE**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cell Means</th>
<th>Critical F (.05)</th>
<th>Null Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td>E: films-only</td>
<td>39.88</td>
<td>48.90</td>
<td>111.76</td>
</tr>
<tr>
<td>Eg: film-guide</td>
<td>39.69</td>
<td>49.52</td>
<td>132.72</td>
</tr>
<tr>
<td>C: control</td>
<td>40.71</td>
<td>45.48</td>
<td>25.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>df(1,120)</td>
</tr>
<tr>
<td></td>
<td>$F_{pre} = .36$</td>
<td>3.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$F_{post} = 7.21$</td>
<td>3.04</td>
<td>Rejected 10</td>
</tr>
<tr>
<td>Treatment Group N = 42</td>
<td>df(2,240)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The significant F values of 111.76, 132.72, and 25.49 for the treatment groups E, Eg, and C, respectively, signify that each treatment group experienced a statistically significant change in "ability to analyze arithmetic computational errors" during the period between pretesting and posttesting. Thus, the null hypotheses 9a, 9b, and 9c are rejected. An inspection of the treatment-group means reported in Table 15 reveals that the change for each group denotes an improvement in ability to analyze computational errors.
Hypothesis 10, the null hypothesis concerned with possible posttest mean differences among the treatment groups, is also rejected on the basis of the statistically significant $F_{post}$ value of 7.21. This result implies that there are differences among treatment-group posttest means and that comparisons between pairs of treatment groups are necessary. The following subhypotheses are postulated:

10a. There is no significant difference between the CEAS posttest mean-scores achieved by the films-only group (E) and film-guide group (Eg).

10b. There is no significant difference between the CEAS posttest mean-scores achieved by the films-only group (E) and control group (C).

10c. There is no significant difference between the CEAS posttest mean-scores achieved by the film-guide group (Eg) and control group (C).

The results of the statistical tests of these hypotheses are reported in Table 16.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Cell Mean</th>
<th>F</th>
<th>Critical $F (.05)$</th>
<th>Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Films-only versus</td>
<td>48.90</td>
<td>.53</td>
<td>3.92</td>
<td>Retain 10a</td>
</tr>
<tr>
<td>Film-guide</td>
<td>49.52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Films-only versus</td>
<td>48.90</td>
<td>20.67</td>
<td>3.92</td>
<td>Reject 10b</td>
</tr>
<tr>
<td>Control</td>
<td>45.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Film-guide versus</td>
<td>49.52</td>
<td>27.79</td>
<td>3.92</td>
<td>Reject 10c</td>
</tr>
<tr>
<td>Control</td>
<td>45.48</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The data provided in Table 16 show that the control-group posttest mean (45.48) is significantly different from each of the experimental-group means (48.90 and 49.52), and that the mean values of the CEAS posttest scores achieved by the experimental groups are not significantly different. This information suggests that, while each of the three groups demonstrated statistically significant improvement in ability to analyze computational errors during the period from pretest to posttest, the groups viewing the films evidenced significantly greater gains than did the group having the live observations.

Hypotheses Eleven and Twelve

11. There is no significant difference between pre- and posttest arithmetic knowledge of pre-service elementary school teachers in treatment group:
   a. E: films only.
   b. Eg: films and film guides.
   c. C: control.

12. There are no significant differences among the posttest arithmetic knowledge of pre-service elementary school teachers in the three treatment groups.

The criterion measurement instrument employed to test these hypotheses was the California Survey of Mathematics Achievement. The multivariate analysis of variance of the scores obtained on this instrument produced the data reported in Table 17, page 123.
TABLE 17
MULTIVARIATE ANALYSIS OF VARIANCE OF STUDENT SCORES ON THE CALIFORNIA SURVEY OF MATHEMATICS ACHIEVEMENT

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Critical F (.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>12,949.9842</td>
<td>125</td>
<td>2.29</td>
<td>.02</td>
<td>3.92</td>
</tr>
<tr>
<td>T (teacher)</td>
<td>2.2857</td>
<td>1</td>
<td>2.29</td>
<td>.02</td>
<td>3.92</td>
</tr>
<tr>
<td>E (experimental)</td>
<td>30.0556</td>
<td>2</td>
<td>15.03</td>
<td>.13</td>
<td>3.07</td>
</tr>
<tr>
<td>TxE</td>
<td>2.4524</td>
<td>2</td>
<td>1.23</td>
<td>.01</td>
<td>3.07</td>
</tr>
<tr>
<td>Subj. W. Groups</td>
<td>12,915.1905</td>
<td>120</td>
<td>107.63</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Within Subjects     | 913.0000       | 126|             |      |                 |
| P = PrexPost        | 311.1111       | 1  | 311.11      | 62.48| 3.92            |
| TxP                 | 4.0635         | 1  | 4.06        | .82  | 3.92            |
| ExP                 | .1032          | 2  | .05         | .01  | 3.07            |
| TxExP               | .1507          | 2  | .08         | .02  | 3.07            |
| PxSubj. W. Groups   | 597.5715       | 120| 4.98        |      |                 |

An inspection of Table 17 reveals the familiar pattern of a statistically significant F value for P (pre-post testing) and nonsignificant F values for all other main effects and effects due to the interaction of the variables. The data reported in Table 17 indicate that there was little differential influence exerted by the two teachers or by the application of treatments. The F value of 62.48 for the main effect P (pre-post testing) signifies that the mean scores of the pre-tests and posttests differ. This suggests that an investigation of the treatment-group pretest and posttest means is warranted. The results of the further analysis of this indicated pre-post difference are reported in Table 18.
### TABLE 18

**COMPARISONS OF TREATMENT-GROUP MEANS FOR THE CALIFORNIA SURVEY OF MATHEMATICS ACHIEVEMENT**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cell Means</th>
<th></th>
<th></th>
<th>Critical F (.05)</th>
<th>Null Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E: films-only</td>
<td>55.69</td>
<td>57.86</td>
<td>19.80</td>
<td>3.92</td>
<td>Reject 11a</td>
</tr>
<tr>
<td>E2: film-guide</td>
<td>56.29</td>
<td>58.55</td>
<td>21.58</td>
<td>3.92</td>
<td>Reject 11b</td>
</tr>
<tr>
<td>C: control</td>
<td>55.50</td>
<td>57.74</td>
<td>21.12</td>
<td>3.92</td>
<td>Reject 11c</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>df(1,120)</td>
<td></td>
</tr>
<tr>
<td>F_{pre}</td>
<td>.13</td>
<td></td>
<td></td>
<td>3.04</td>
<td></td>
</tr>
<tr>
<td>F_{post}</td>
<td>.14</td>
<td></td>
<td></td>
<td>3.04</td>
<td>Retain 12</td>
</tr>
</tbody>
</table>

Treatment Group N = 42 df(2,240)

The data reported in Table 18 indicate that the pretest and posttest means differ significantly for each of the three treatment groups, therefore the null hypotheses 11a, 11b, 11c are rejected. Since the F_{post} value is not significant, the null hypothesis concerning posttest mean differences is retained.

An inspection of the two sets of means shows that each pre-post change denotes an "improvement" in mathematics achievement. The reader should also note that the indicated mean difference for each treatment group is small relative to the magnitude of the test scores. The most reasonable explanation for the highly significant F values in the face of relatively small mean differences appears to depend upon the pattern of pre-post change exhibited by the subjects involved in this study. An examination of the raw data reveals a consistent pattern of moderate pre-post increases for large numbers of students rather than unusually large pre-post increases for a few individuals and little or no pre-post deviation for the others. Uniform, moderate variations of the kind
manifested by the subjects in this study tend to be capable of producing statistical significance for extremely small mean-score differences.

Hypotheses Thirteen and Fourteen

13. There is no significant difference between pre- and posttest opinions of pre-service elementary school teachers in each treatment group relative to the need for live observations as a component part of a teaching-methods course. This hypothesis is postulated for treatment group:
   a. E: films only.
   b. Eg: films and film guides.
   c. C: control.

14. There are no significant differences among the posttest opinions of pre-service elementary school teachers in the three treatment groups concerning the need for live observations as a component part of a teaching-methods course.

The criterion measurement instrument employed to test these hypotheses was the Dutton Scale Supplement Item Number 3:

Place a circle around one number to show how you feel about the importance of including live observations of student-learning activities as a component part of a teaching-methods course.

1 2 3 4 5 6 7 8 9 10 11
Nonessential Essential
TABLE 19

MULTIVARIATE ANALYSIS OF VARIANCE OF STUDENT
RESPONSES TO ITEM THREE OF THE
DUTTON SCALE SUPPLEMENT

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Critical F (.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>1,043.7143</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T (teacher)</td>
<td>.3968</td>
<td>1</td>
<td>.40</td>
<td>.05</td>
<td>3.92</td>
</tr>
<tr>
<td>E (experimental)</td>
<td>31.5238</td>
<td>2</td>
<td>15.76</td>
<td>1.87</td>
<td>3.07</td>
</tr>
<tr>
<td>TxE</td>
<td>2.5079</td>
<td>2</td>
<td>1.25</td>
<td>.15</td>
<td>3.07</td>
</tr>
<tr>
<td>Subj. W. Groups</td>
<td>1,009.2858</td>
<td>120</td>
<td>8.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td>383.0000</td>
<td>126</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P = PrexPost</td>
<td>20.5714</td>
<td>1</td>
<td>.20.57</td>
<td>8.09</td>
<td>3.92</td>
</tr>
<tr>
<td>TxD</td>
<td>.5714</td>
<td>1</td>
<td>.57</td>
<td>.22</td>
<td>3.92</td>
</tr>
<tr>
<td>ExP</td>
<td>56.8571</td>
<td>2</td>
<td>28.43</td>
<td>11.19</td>
<td>3.07</td>
</tr>
<tr>
<td>TxEExP</td>
<td>.0001</td>
<td>2</td>
<td>.00</td>
<td>.00</td>
<td>3.07</td>
</tr>
<tr>
<td>PxSubj. W. Groups</td>
<td>305.0000</td>
<td>120</td>
<td>2.54</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Two significant F values are found in Table 19. The main effect
P (pre-post testing) exhibits an F of 8.09 and the ExP interaction effect,
F = 11.19, is also statistically significant. Together, these two fac-
tors imply that significant changes from pretest to posttest occurred for
at least one of the treatment groups and that the experimental treat-
ment was influential in producing a differential effect among the groups.
The pre-post means tabulated in Table 20 provide a clue to the manner in
which these effects are evidenced.
A comparison of the pretest and posttest means reported in Table 20 reveals that at the conclusion of the study, members of both experimental groups generally rated the "need for live observations" lower than they did at the beginning of the investigation. The indicated change is statistically significant for each group with $F = 9.91$ and $F = 15.76$ for the films-only and film-guide groups, respectively, and the null hypotheses 13a and 13b are rejected. On the other hand, the members of the control group tended to rate the "need for live observations" higher on the posttest than they did on the pretest. An $F = 4.80$ indicates that this change was significant at the .05 level, therefore the null hypothesis 13c is rejected.

The $F_{pre} = .21$ reported in Table 20 signifies that there are no significant pretest mean differences among the treatment groups while the $F_{post} = 7.86$ indicates that significant posttest mean differences do exist. Therefore, hypothesis 14 is rejected.
The rejection of the hypothesis of no significant differences among the three treatment-group posttest means suggests that an inquiry into the character of the relationship between paired treatment groups should be made. The following subhypotheses are postulated to facilitate such an inquiry:

14a. There is no significant difference between the mean ratings obtained by the films-only group (E) and the film-guide group (Eg) on Item 3 of the Dutton Scale Supplement.

14b. There is no significant difference between the mean ratings obtained by the films-only group (E) and the control group (C) on Item 3 of the Dutton Scale Supplement.

14c. There is no significant difference between the mean ratings obtained by the film-guide group (Eg) and the control group (C) on Item 3 of the Dutton Scale Supplement.

A tabulation of the results of the statistical tests of these three subhypotheses is found in Table 21.

**TABLE 21**

**COMPARISONS OF POSTTEST TREATMENT-GROUP MEANS FOR ITEM THREE ON THE DUTTON SCALE SUPPLEMENT**

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Cell Mean</th>
<th>F</th>
<th>Critical F (.05)</th>
<th>Null Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Films-only versus</td>
<td>7.79</td>
<td>.12</td>
<td>3.92</td>
<td>Retain 14a</td>
</tr>
<tr>
<td>Film-guide</td>
<td>7.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Films-only versus</td>
<td>7.79</td>
<td>23.61</td>
<td>3.92</td>
<td>Reject 14b</td>
</tr>
<tr>
<td>Control</td>
<td>9.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Film-guide versus</td>
<td>7.67</td>
<td>27.05</td>
<td>3.92</td>
<td>Reject 14c</td>
</tr>
<tr>
<td>Control</td>
<td>9.48</td>
<td></td>
<td>df(1,120)</td>
<td></td>
</tr>
</tbody>
</table>
The data in Table 21 demonstrate that the mean posttest ratings of the two experimental groups do not differ significantly, hence the null hypothesis 14a is retained. In both instances where the control group was compared, in turn, to each of the experimental groups, statistically significant F values were obtained. Hence, the null hypotheses 14b and 14c are rejected.

**Hypotheses Fifteen and Sixteen**

15. There is no significant difference between pre- and post-test expressions of approval by pre-service elementary school teachers in each treatment group relative to the use of films to replace live observations. This hypothesis is postulated for treatment group:

a. E: films only.

b. Eg: films and film guides.

c. C: control.

16. There are no significant differences among posttest expressions of approval by pre-service elementary school teachers in the three treatment groups relative to the use of filmed observations to replace live observations.

The criterion measurement instrument employed to test these hypotheses was the Dutton Scale Supplement Item 4:

Place a circle around one number to show how you feel about the use of the NCTM films to replace live classroom observations.

1 2 3 4 5 6 7 8 9 10 11

Disapprove

Approve
**TABLE 22**

**MULTIVARIATE ANALYSIS OF VARIANCE OF STUDENT RESPONSES TO ITEM FOUR OF THE DUTTON SCALE SUPPLEMENT**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Critical F (.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td>833.6032</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T (teacher)</td>
<td>.5714</td>
<td>1</td>
<td>.57</td>
<td>.08</td>
<td>3.92</td>
</tr>
<tr>
<td>E (experimental)</td>
<td>16.8174</td>
<td>2</td>
<td>8.41</td>
<td>1.24</td>
<td>3.07</td>
</tr>
<tr>
<td>TxE</td>
<td>.1667</td>
<td>2</td>
<td>.08</td>
<td>.01</td>
<td>3.07</td>
</tr>
<tr>
<td>Subj. W. Groups</td>
<td>816.0477</td>
<td>120</td>
<td>6.80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Within Subjects              | 280.0000       | 126|             |     |                 |
| P = PrexPost                 | 51.5714        | 1  | 51.57       | 32.42| 3.92            |
| TxP                          | .0000          | 1  | .00         | .00 | 3.92            |
| Exp                          | 37.4524        | 2  | 18.73       | 11.77| 3.07            |
| TxE Exp                      | .0715          | 2  | .04         | .02 | 3.07            |
| PxSubj. W. Groups            | 190.9047       | 120| 1.59        |     |                 |

Table 22 reveals that the main effect P (pre-post testing) and the ExP interaction effect each produced a significant F value. The first value, F = 32.42, testifies to a significant pattern of change between the pretest and posttest results, while the second value, F = 11.77, indicates that the experimental treatment exerted a significant influence on the aforementioned pattern of change. Since all other F values in this table are nonsignificant, further investigations of the other interactions and main effects appear to be unwarranted.

The TxP value of zero (.0000) indicates that the gains or losses from pre- to posttest for corresponding classes receiving the same treatment are virtually the same for each of the two teachers involved in the
study. A numerical value greater than zero would be obtained if the
calculation were carried out to a greater number of decimal places.

A comparison of the treatment-group means, reported in Table 23,
gives some indication of the differential influence of the experimental
treatment.

TABLE 23

COMPARISONS OF THE TREATMENT-GROUP MEANS FOR
ITEM FOUR OF THE DUTTON SCALE SUPPLEMENT

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cell Means</th>
<th></th>
<th>Critical F (.05)</th>
<th>Null Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>E1: films-only</td>
<td>6.57</td>
<td>7.74</td>
<td>17.97</td>
<td>3.92</td>
</tr>
<tr>
<td>E2: film-guide</td>
<td>6.67</td>
<td>8.36</td>
<td>37.72</td>
<td>3.92</td>
</tr>
<tr>
<td>C: control</td>
<td>6.95</td>
<td>6.81</td>
<td>.27</td>
<td>3.92</td>
</tr>
</tbody>
</table>

\[ \text{df}(1, 120) \]

\[ \text{F}_{\text{pre}} = 0.39 \]
\[ \text{F}_{\text{post}} = 6.07 \]

Null Hypothesis: Reject 16

Treatment Group N = 42 \[ \text{df}(2, 240) \]

An inspection of the two sets of cell means listed in Table 23 shows that the posttest means of the experimental groups are greater than the pretest means. This indicates that at the conclusion of the study, members of the E (films-only) and E2 (film-guide) groups gave greater approval to the use of films to replace live observations than they did at the time the study was initiated. This change was statistically significant for each of the experimental groups.

The data in Table 23 also reveal that the posttest mean for the C (control) group is slightly lower than the pretest mean, but the change is not statistically significant at the .05 level. The \[ \text{F}_{\text{pre}} = 0.39 \] indicates that no significant mean differences existed among the
treatment groups at the beginning of the study. The $F_{\text{post}} = 6.07$
suggests that there are significant mean differences among the posttest
means. Further investigation of these implied posttest mean differences
is facilitated by postulating the following hypotheses:

16a. There is no significant difference between the posttest
mean ratings obtained by the films-only group (E) and the
film-guide group (Eg) on Item 4 of the Dutton Scale
Supplement.

16b. There is no significant difference between the posttest
mean ratings obtained by the films-only group (E) and the
control group (C) on Item 4 of the Dutton Scale
Supplement.

16c. There is no significant difference between the posttest
mean ratings obtained by the film-guide group (Eg) and the
control group (C) on Item 4 of the Dutton Scale
Supplement.

Statistical tests of these hypotheses are reported in Table 24,
page 133. These data provide some insight into the relationship among
the three treatment-group posttest means. The first comparison, i.e.,
films-only (E) and film-guide (Eg), yielded an $F$ value of 5.05 which is
statistically significant at the .05 level, thus the hypothesis of no
mean difference, 16a, is rejected. A glance at the table reveals that
the mean of the film-guide group is greater than the mean of the films-
only group. The second comparison, i.e., films-only (E) and control (C),
also produced a significant $F = 11.38$ which is sufficient evidence to
reject hypothesis 16b. An inspection of the means of these two treatment
groups discloses that the films-only group has a mean which is greater
than the mean of the control group. Thus, the posttest means of the three treatment groups can be ordered in the following manner:

$6.81 < 7.74 < 8.36$. The second mean (7.74) is significantly greater than the first (6.81) and the third mean (8.36) is significantly greater than the second. It is anticlimatic to note that the third comparison indicated a significant difference between the means of the film-guide group and the control group.

**TABLE 24**

**COMPARISONS OF POSTTEST TREATMENT-GROUP MEANS FOR ITEM FOUR ON THE DUTTON SCALE SUPPLEMENT**

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Cell Mean</th>
<th>F</th>
<th>Critical F (.05)</th>
<th>Null Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Films-only versus</td>
<td>7.74</td>
<td>5.05</td>
<td>3.92</td>
<td>Reject 16a</td>
</tr>
<tr>
<td>Film-guide</td>
<td>8.36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Films-only versus</td>
<td>7.74</td>
<td>11.38</td>
<td>3.92</td>
<td>Reject 16b</td>
</tr>
<tr>
<td>Control</td>
<td>6.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Film-guide versus</td>
<td>8.36</td>
<td>31.62</td>
<td>3.92</td>
<td>Reject 16c</td>
</tr>
<tr>
<td>Control</td>
<td>6.81</td>
<td></td>
<td></td>
<td>df(1,120)</td>
</tr>
</tbody>
</table>

These data would seem to indicate that at the conclusion of the study, the individuals in the control group held about the same opinion regarding the use of films to replace observations as they did at the beginning. The experimental groups, however, tended to express greater approval of the utilization of the films for such purposes at the time of the posttest than they did at the time of the pretest. In addition, the film-guide group gave significantly stronger approval to the use of the films than did the films-only group.
Summary

The purpose of this study was to investigate the possible utilization of a series of ten films as replacements for ten laboratory sessions in an arithmetic content-methods course for pre-service elementary school teachers. Several hypotheses were postulated about the prospective teachers' attitude toward arithmetic, knowledge of arithmetic, ability to analyze computational errors, and general feelings about a number of aspects related to the use of the films as replacements for live observations.

A pre- and posttest multivariate statistical design was employed to test these hypotheses. Three main effects were investigated: (1) a teacher effect, (2) a treatment effect, and (3) a pre-post test effect. The statistical design provided for the exploration of the various interactions between and among these three main effects. \( F_{max} \) tests for homogeneity of variance and ordinary 1x6 analyses of variance for each instrument indicated that the initial status of each of the six classes involved in the study was such that all six could be considered to be representative samples of the same population.

In general, the use of two teachers, each teaching three classes, appeared to have had little or no effect on the results obtained. Efforts were made to minimize the effect of this particular variable and there was some evidence that these efforts were successful. An inspection of each one of the eight Multivariate Analysis of Variance tables reveals that neither the teacher main effect nor any interaction involving the teacher variable achieved a significant \( F \) value. This would suggest that differential teacher influences were negligible. The lack of statistically significant teacher interaction, together with appropriate tests for
homogeneity of variance and mean differences between groups receiving the same treatment led to the combining of the scores of these classes for "treatment-group" comparisons.

Although the teacher variable appeared to have exerted practically no differential influence on measured results, the multivariate analysis of variance demonstrated that the pre-post main effect produced a statistically significant F value in every instance. This indicated that changes from pretest to posttest had occurred. Further investigation of these changes revealed a general pattern of development for several of the tests. These findings are summarized below by posing questions similar to those which generated the hypotheses tested, followed by the results of the analysis. The "change" referred to in each question is presumed to have occurred during the semester which encompassed the study and to have been measured by the specified instrument in conjunction with the pretest-posttest device.

1. Did students experience changes in attitude toward arithmetic?

Yes. Examination of Table 7 indicates that students in each treatment group achieved significantly greater posttest mean scores on the Dutton Attitude Toward Arithmetic Scale. The greater score signifies that the change was in the positive direction. Table 7 also shows that no statistically significant differences among posttest treatment-group mean scores existed, thus there appeared to be no differential effect due to treatments.

2. Did students experience changes in general feelings about arithmetic?

Yes. Examination of Table 9 indicates that each treatment group achieved significantly higher posttest mean "scores" on Item 16 of the
Dutton Attitude Toward Arithmetic Scale. A high rating on this item signifies a greater degree of "like" for arithmetic. Table 9 also reveals that no significant mean differences among the three treatment groups were detected, thus there appeared to be no differential effect due to treatments.

3. Did students experience changes in confidence in their ability to teach "modern mathematics"?

Yes. Examination of Table 11 indicates that each treatment group evidenced significantly higher posttest mean "scores" on Item 1 of the Dutton Scale Supplement. The highest rating on this particular scale indicates extreme confidence. Table 11 also reveals that no significant mean differences among the three treatment groups were detected, thus there appeared to be no differential effect due to treatments.

4. Did students experience changes in belief in the ability of elementary school pupils to learn "modern mathematics"?

Yes. Examination of Table 13 indicates that each treatment group evidenced significantly higher posttest mean "scores" on Item 2 of the Dutton Scale Supplement. The highest rating on this particular scale indicates that the rater believes that it is quite likely that children will be able to acquire the concepts and skills inherent in a "modern mathematics" instructional program. Table 13 also reveals that no significant mean differences among the three treatment groups were detected, thus there appeared to be no differential effect due to treatments.

5. Did students experience changes in knowledge of arithmetic during the course of the study?
Yes. Examination of Table 18 indicates that each treatment group achieved a significantly greater posttest mean score on the California Survey of Mathematics Achievement. This table also reveals that no significant mean differences were detected among the three treatment groups, thus there appeared to be no differential effect due to treatments.

The answers to the five previous questions exhibit a similar pattern. First, each treatment group experienced a statistically significant change from pretest to posttest as measured by the specified instrument. Second, the direction of the change was the same for each treatment group. Third, the magnitude of the change was approximately the same for each treatment group since no significant differences were detected among the treatment-group pretest means or, subsequently, among the treatment-group posttest means. The answers to the following questions do not conform to this general pattern.

6. Did students experience changes in ability to analyze computational errors?

Yes. Examination of Table 15 indicates that each treatment group achieved a significantly greater posttest mean score on the Computational-Error Analysis Scale. The changes reflected by the three groups were in the same direction indicating improved ability to analyze computational errors. In addition, Table 16 reveals that each experimental group achieved a posttest mean score which was significantly greater than the posttest mean score obtained by the control group. It should be noted that any apparent difference between the mean scores achieved by the two experimental groups was not statistically significant.
7. Did students experience changes in opinion regarding the need for live observations in a teaching-methods course?

Yes. Examination of Table 20 indicates that the posttest mean "score" for each treatment group differed significantly from its pretest "score." The direction of the change, however, was not the same for each treatment group. The two experimental groups produced significantly lower posttest mean "scores" while the control group achieved a significantly higher mean "score" on the posttest. Table 21 shows that the difference between the posttest means of the two experimental groups was not statistically significant. These data tend to show that at the time of the posttest the members of the experimental groups felt less need for live observations in a "teaching-methods" course than did the members of the control group.

8. Did students experience changes in opinion regarding the use of films to replace live observations?

This question must receive a qualified yes, because an examination of Table 23 indicates that no statistically significant difference was found between the pre-post mean "scores" of the control group. On the other hand, each of the experimental groups evidenced a significantly higher posttest mean "score." These changes exhibited by the experimental groups were both in the same direction and indicated approval of the utilization of the MET films to replace live observations. The film-guide group manifested a significantly greater change in this direction than did the films-only group.

The main differences between the patterns disclosed by the answers to the last three questions and the pattern associated with the first five questions centers on the differential posttest effect due to
treatments. It may well be that the essence of this study rests on this particular dissimilarity.
CHAPTER V

SUMMARY AND CONCLUSIONS

Summary of the Design and Analysis

This study was designed to determine whether the ten-film series, Mathematics for Elementary School Teachers (MET), was as efficacious as live observations of teaching in a required course for pre-service elementary school teachers at Wisconsin State University-Oshkosh. Elementary education students who enrolled in this course during the fall semester of 1968 were randomly assigned to one of six sections scheduled in pairs at three different time intervals. Two instructors and three treatments were involved in this study. Each teacher was assigned one films-only class, one film-guide class, and one live-observation or control class.

The main purpose of this study was to secure data which would provide a basis for accepting or rejecting the MET-film series as a substitute for the live observations traditionally included in the laboratory activities of the course Content and Methods of Elementary Arithmetic. The films were evaluated in terms of the presumed contributions made to the instructional program by the observations. Educative contributions attributed to the live observations were the following:

1. Observations tended to improve the prospective teachers' attitude toward arithmetic.

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2. Observations strengthened the prospective teachers' belief in the ability of elementary school children to acquire the concepts and skills of a "modern mathematics" instructional program.

3. Observations helped prospective teachers develop confidence in their ability to teach "modern mathematics."

4. Observations provided opportunities for prospective teachers to acquire skill in analyzing arithmetic computational errors.

The substantive ideas expressed in these presupposed contributions together with the students' knowledge of arithmetic and feelings about the use of the films to replace live observations were used to define the criterion variables.

A pre-post $2 \times 3 \times 2$ (Teacher x Experimental Treatment x Pre-Post) factorial design was employed with repeated measures (pre-post testing) on the third factor. Twenty-one subjects from each of the six classes were included in the final statistical analyses. For these 126 subjects, scores were obtained on the following measures:

1. College mathematics grade-point averages.
2. Composite American College Test Score.
4. Dutton Attitude Toward Arithmetic Scale.
5. Computational-Error Analysis Scale.

The first two instruments listed above were used as initial control measures. The last four instruments identified in the list were employed as pre-post measures.
The statistical design of the study was selected because it would provide information about changes occurring over the course of the semester, it would enable the investigator to compare treatment effects, and it would furnish information about the interaction of the main variables. A multivariate analysis of variance was employed to pinpoint the significant main effects or interaction effects requiring further investigation. Once identified, these effects were further analyzed to ascertain specific relationships between and among treatment groups. All tests of significance were made at the .05 level.

Findings

1. The six classes did not differ significantly on any of the pretests. In particular, the analyses of variance computed for each of the control measures, i.e., College Mathematics Grade-Point Averages and Composite American College Test Scores, yielded F values of 1.77 and 1.29, respectively. Neither of these values was significant at the .05 level with df(5,120). Similar results were obtained for each of the other pretest measures when one-by-six analyses of variance were computed.

2. There was no significant main effect due to the teacher variable, nor was there any significant interaction effect attributed to the use of two teachers. This fact, together with nonsignificant mean differences and homogeneity of variances for each pair of classes receiving the same experimental treatment permitted investigation of the pooled scores of these paired groups.

3. All treatment groups evidenced significantly more positive attitudes toward arithmetic at the conclusion of the study than they did
at the beginning, although no significant posttest mean differences were detected among treatment groups.

4. All treatment groups expressed a significantly greater degree of "like" for arithmetic at the conclusion of the study than they did at the beginning, although no significant posttest mean differences were detected among treatment groups.

5. All treatment groups expressed a significantly greater degree of confidence in their ability to teach "modern mathematics" at the conclusion of the study than they did at the beginning, although no significant posttest mean differences were detected among the treatment groups.

6. All treatment groups expressed significantly stronger beliefs in the ability of children to learn "modern mathematics" at the conclusion of the study than they did at the beginning, although no significant posttest mean differences were detected among treatment groups.

7. All treatment groups demonstrated significantly greater knowledge of arithmetic at the conclusion of the study than they did at the beginning, although no significant posttest mean differences were detected among treatment groups.

8. All treatment groups demonstrated significantly greater skill in analyzing elementary computational errors at the conclusion of the study than they did at the beginning. The posttest revealed that the experimental groups, i.e., those groups which viewed the films, exhibited significantly greater skill in this respect than the live-observation group. There was no significant difference between the posttest scores of the two experimental groups.
9. In reference to the opinions of students with regard to the need for live observations in a teaching-methods course, both experimental groups felt that live observations were significantly less essential than did the control group. In fact, the experimental groups each experienced a statistically significant negative change from their pretest position, i.e., at the time of the pretest they seemed to feel that live observations were quite essential. This apparent deterioration in belief that live observations are necessary was of about the same magnitude for each group. On the other hand, the control group experienced a statistically significant "strengthening" of their belief in the need for live observations from pretest to posttest.

10. In reference to the opinions of students regarding the substitution of films for live observations, the feelings expressed by the control group were approximately the same at the beginning and at the end of the study. The experimental group which received the films-only treatment gave significantly stronger approval to the use of films at the conclusion of the study compared to their pretest ratings. The film-guide group surpassed that point, indicating a degree of approval which was significantly greater than the films-only group. Of course, both experimental groups manifested a degree of approval which was significantly different from that of the control group.

Cautions in Interpreting Results

The major limitations of this study were detailed in Chapter III. A brief review is included at this point as a precaution immediately prior to the statement of the conclusions and implications.
The sample selected was presumed to be representative of the population of students enrolled in Elementary Education at Wisconsin State University-Oshkosh. These students exhibited a fairly uniform college-level mathematics background, probably because, for most of them, their only experience with "modern mathematics" consisted of the college mathematics which was prerequisite to the course in which this study was conducted.

The validity and reliability of the measuring instruments employed to obtain the results of this study must be interpreted and judged by the reader.

The vocabulary employed in the Computational-Error Analysis Scale was appropriate for the subjects included in this study, but it may not be suitable for student populations at other institutions.

Finally, the use of the same instruments in the pre-post phase of the study may have had certain drawbacks. The most important mitigating circumstance pertinent to this point was that the tests were administered approximately four months apart, so it was assumed that minimal recall effects were operative. In addition, except for the Survey of Arithmetic and the Computational-Error Analysis Scale, the instruments employed were free-choice, self-rating, opinionnaire-type "tests" which made questions of "remembering" certain items somewhat irrelevant to the utility of the device.

**Conclusions and Implications**

Within the boundaries of the limitations previously described, the following conclusions seem warranted:
1. For pre-service elementary school teachers enrolled in the course Content and Methods of Arithmetic at Wisconsin State University-Oshkosh, the film series Mathematics for Elementary School Teachers was no less effective than live observations in the University Campus School in:

   a. Producing improved student attitudes toward arithmetic.
   b. Increasing student confidence in their ability to teach "modern" elementary school mathematics.
   c. Strengthening student belief in the ability of elementary school children to acquire the concepts and skills which are inherent in a "modern mathematics" instructional program.
   d. Improving student knowledge of arithmetic.

   The use of the phrase "was no less effective" in the statement above was intentional. To have said "was equally effective" or "was as effective as" would have been to imply that the live observations were actually known to "effect" the four aspects of achievement described above. This was not the case, however. It may well have been true that some variable totally unrelated to the laboratory activities was responsible for "effecting" those changes, therefore, it seemed that the weaker phrase "was no less effective" was more appropriate than any other.

   2. For pre-service elementary school teachers enrolled in the course Content and Methods of Elementary Arithmetic at Wisconsin State University-Oshkosh, the film series Mathematics for Elementary School Teachers was more effective than live observations of teaching in developing student ability to analyze elementary computational errors.
The superiority of the films in developing student ability to analyze computational errors was probably due to the fact that the "film" teacher often discussed a particular mathematical principle and identified errors which might occur when a child did not understand the principle. His exposition was immediately followed by a classroom scene to illustrate the point. Although the first two phases of this procedure were accomplished in the regular classroom, it was impractical, if not impossible, to duplicate the third feat. Seemingly, contiguity was the prime operative factor. The ease of coupling "mathematical principle, associated error, and illustrative example" on film was sharply contrasted with the necessary time lapse between classroom discussions and live observations.

3. Results of this study indicate that the use of the films tended to weaken preconceived notions many students held regarding the necessity for live observations of teaching as a component part of a teaching-methods course. Both experimental groups exhibited a significant shift away from their initial position regarding the need for live observations, and the shift was in the direction which indicated that they felt live observations were nonessential. The control group, to the contrary, appeared to be more firmly convinced that live observations were essential at the time of posttesting. Perhaps the only legitimate conclusion is that the students were influenced by and tended to approve the type of laboratory activities in which they participated. The implication seems to be that students regarded the laboratory phase of the course as an important part of the course whether the observations were filmed or live.
4. There seems to be sufficient evidence to conclude that students who viewed the films approved of substituting films for live observations. Each of the groups which viewed the films exhibited a significant opinion change in the direction of greater approval, while the control group expressed approximately the same feelings at the beginning and at the end of the study. This result tends to support the previous conclusion that the experimental groups felt that live observations were not essential in a "teaching-methods" course.

5. The film guides appeared to have had little differential effect in the study. Only on the item having to do with the approval of substituting the films for live observations did the film-guide group differ significantly from the other two groups.

The fundamental implication, emanating from this study, is that the MET films can be utilized to replace live observations in the course Content and Methods of Arithmetic. The evidence provided by this study indicates that, in most respects, the film series and the live observations produce very similar results.

A further implication would be that the films (or a carefully selected subset of the films) could be used in a beneficial manner as an adjunct to live observations. The apparent superiority of the films in developing the students' ability to analyze computational errors would seem to indicate that the films could effectively be used to develop this particular skill.

Suggestions for Further Research

The design of this study precluded drawing firm conclusions about the "equality" of effectiveness of the films and live observations.
One suggestion for future research would be to devise an investigation similar to this one, but including a no-observation group. A study involving a no-observation group might produce evidence which would lend credence to the notion that the films and live observations are "equally effective" when significant pre-post changes are detected but no significant differences are found among the posttest means. The doubt surrounding the possibility of an extraneous variable inducing the observed pre-post change might well be removed.

Another avenue of inquiry could focus attention on the use of a subset of the films. Although each film is a high-quality production, differences in emphasis on lecture, demonstration, use of classroom scenes, etc., do exist. Investigations could be designed to ascertain the usefulness of specific films for particular purposes. For example, the four films dealing with the properties of addition, subtraction, multiplication, and division might be more effective in changing student attitudes, while the corresponding films treating the algorithms might be most effective in developing the students' ability to analyze computational errors. Another possibility is a comparison between those films containing the greatest number and the least number of classroom scenes.

A third possibility for further research has to do with the order in which the films are shown. This study used the films in the sequence "suggested" by the producer. Essentially, this means that the films treating the properties of the four arithmetic operations with whole numbers occur first and the films dealing with the algorithms associated with these operations occur last. Another suggested sequence which could be investigated would be to follow each film identifying.
properties of a given operation with the film treating the algorithms pertaining to that operation.

Finally, replications of this study would be helpful in substantiating or refuting conclusions induced by this investigation. It was pointed out in the literature review that one of the most serious defects of media research has been the lack of replication. One of the principal reasons for selecting the MET-film series was to employ a set of films which was accessible to a great number of potential researchers. Since these films are widely available at reasonable rates, it would seem that replication studies could be implemented with ease.
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Books


Periodicals


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Ohles, John F. "Is the Laboratory School Worth Saving?" The Journal of Teacher Education, 18 (Fall, 1967) 304.


General Reference Works


Bulletins


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Unpublished Material


Tests

APPENDIXES
APPENDIX A

Raw Data
RAW DATA

Q: THE DUTTON ATTITUDE TOWARD ARITHMETIC SCALE.

\( Q_1: \) PRETEST.
\( Q_2: \) POSTTEST.

R: COMPUTATIONAL-ERROR ANALYSIS SCALE.

\( R_1: \) PRETEST.
\( R_2: \) POSTTEST.

S: SURVEY OF MATHEMATICS ACHIEVEMENT.

\( S_1: \) PRETEST.
\( S_2: \) POSTTEST.
RAW DATA - SECTION I

Teacher 1 Treatment E

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V: ITEM 16 - DUTTON ATTITUDE TOWARD ARITHMETIC SCALE.
   V₁: PRETEST.
   V₂: POSTTEST.

W: ITEM 1 - DUTTON SCALE SUPPLEMENT.
   W₁: PRETEST.
   W₂: POSTTEST.

X: ITEM 2 - DUTTON SCALE SUPPLEMENT.
   X₁: PRETEST.
   X₂: POSTTEST.

Y: ITEM 3 - DUTTON SCALE SUPPLEMENT.
   Y₁: PRETEST.
   Y₂: POSTTEST.

Z: ITEM 4 - DUTTON SCALE SUPPLEMENT.
   Z₁: PRETEST.
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APPENDIX B

Film Guides
Film #1 - Beginning Number Concepts

This film is the first in a series of ten 30-minute films entitled Mathematics for Elementary School Teachers. These films were prepared by The National Council of Teachers of Mathematics and were designed to provide instruction in mathematics for in-service elementary school teachers. Each film introduces several basic mathematical concepts, describes the importance of these concepts in mathematics instruction, and illustrates various ways in which these fundamental ideas could be presented to elementary school children in order to develop mathematical understanding. The scope of the topics embodied in this series of ten films is limited to the properties of the set of whole numbers and the four fundamental arithmetic operations on this set of elements. The film teacher is Professor John Moray of San Jose State College, San Jose, California.

Film #1 specifically treats three basic concepts of arithmetic, i.e., (1) the one-to-one correspondence, (2) the concept of number, and (3) the process of counting. The film instructor, Professor Moray, initiates this particular lesson by considering situations which may have motivated primitive man to develop number concepts and he suggests that very young children tend to recapitulate the mathematical experiences of ancient man. Employing a small flock of sheep, a handful of pebbles, and a matching process, Mr. Moray illustrates the manner in which early man did and young children might devise a method to determine an answer to the question - "How many sheep?" - without counting and without reference to the concept of number. In addition, this matching process yields a result which can be used as a record to check the "count" at some subsequent time. He also points out that children often use their fingers rather than pebbles because fingers are more convenient objects to utilize during the matching process.

The scene then shifts to a first-grade classroom where youngsters are being introduced to the technique of matching sets of objects. A magnetic board with animal silhouettes is utilized to develop notions of "matching," "one-to-one correspondence," "equivalent sets," and "non-equivalent sets." During this classroom presentation, please note the following events:

1) The teacher encourages active participation on the part of the pupils.

2) Watch for the little girl who attempts to match five "pigs" with four "horses." Note particularly that she is not permitted to exhibit what she planned to do with the extra pig.

3) When the teacher prepares to enunciate the term "not equivalent," note that several of the children seem to be lip reading, because these youngsters are forming the "n" sound before the teacher pronounces the word "not."
After the classroom shot, the scene shifts to a lecture-demonstration situation during which Professor Moray explains the need for some prior knowledge of set theory before attempting to develop the concept of "matching." Subsequently, he demonstrates that the one-to-one correspondence is a special type of matching, that this type of correspondence is used to define equivalent sets, and that a thorough understanding of equivalent sets must precede an understanding of number. Professor Moray also discusses the distinction between number and numeral. Later, he employs representative sets and the matching technique to develop the notion of more and fewer elements in two sets which are not equivalent, and the ideas of greater than and less than with reference to numbers. This ordering process, together with the proper counting-order of the number names, are seen to be necessary prerequisites for learning to count in order to determine the number of elements in a given finite set.

Finally, the concept of zero is introduced and the set of whole numbers and the set of counting numbers are compared. The final portion of the film summarizes the preceding activities and it offers some justification for teaching basic concepts to build understanding rather than drilling for skill in computation alone.

Preview: Things to watch for in the film -

1) The types of sets deemed appropriate for early elementary learning activities.
2) The set notation employed by the film teacher.
3) The activities of the students in the classroom scene.
4) The definitions of 1:1 correspondence and equivalent sets.
5) The explanation of the meaning of the terms number and numeral.
6) The distinction between "more and fewer" and "greater than and less than."
7) The explanation of the meaning of counting.
8) The techniques used to develop the notion that zero is a number.

Postview: Be prepared to answer the following -

1) Consider the statement: "Every elementary-school teacher should know some of the history of mathematics!" Agree or disagree and justify your position with an explicit argument.
2) Compare the terms "matching" and "one-to-one correspondence" used by Professor Moray. Describe the manner in which these expressions are similar and how they differ.
3) Sketch a lesson plan and describe the activities you would employ to develop the concept of one-to-one correspondence at the first grade level.

4) Describe one way in which a teacher could "teach" the meaning of equivalent sets.

5) Distinguish between the terms number and numeral.

6) Distinguish between the terms more and greater than; fewer and less than.

7) State some of the fundamental reasons for stressing basic concepts rather than computational techniques in a modern arithmetic program.
This film is the second in the National Council of Teachers of Mathematics series for elementary school teachers and in this lesson, Professor Moray presents some of the fundamental ideas which describe the structure of "our" system of naming numbers. He calls attention to these ideas by considering several ancient numeration systems and by identifying those aspects of these early systems which proved to be useful and consequently are incorporated into the system which we know and use today. In addition, he describes those features which were discarded or reformulated in order to overcome some of the difficulties inherent in the older systems. This lesson is organized to refute the common notion that "our" system of numeration is the first and only system ever employed by man. The stated purpose of the lesson is to "bring out ideas which are important for an understanding of 'our' system of naming numbers," an understanding needed to grasp the essence of arithmetic and/or arithmetic teaching.

At the beginning of the lesson, Professor Moray states that man's earliest attempts to record numerical data probably focused on simple tally marks of one sort or another. Later, when it became necessary to deal with greater and greater numbers, more sophisticated numeration systems were required and devised. The nature of the known early numeration systems lead us to believe that the grouping of tally marks was the first innovation in the direction of greater sophistication.

In succession, the Egyptian, the Roman, and the Babylonian systems of numeration are described. Professor Moray emphasizes that each of these systems employed the repetition of symbols and an additive feature, and that all three of the systems lacked a system of true positional notation. He also points out the historical trend to shorten and simplify the methods of naming numbers, a trend which subsequently produced a symbol for zero and true positional notation.

This filmed presentation makes it clear that the early numeration systems were not well-suited for computational purposes, thus computing devices such as the abacus were necessary to perform calculations. The film utilizes several scenes to illustrate the manner in which the abacus was used to compute and to demonstrate the way in which this simple "calculating machine" can be used as a teaching aid in a modern classroom.

"Our" system of numeration, the so-called Hindu-Arabic system, is shown to have three important features which earlier systems lacked. First, it utilizes nine different digit-symbols to identify numbers associated with sets containing from one to nine elements. Second, it employs a digit-symbol for zero to identify the number of elements in the empty set. Finally, it uses positional notation. Great emphasis is placed on the need for devising a symbol for zero before true positional notation could be utilized.
The manner in which we group three digits into "periods" within Hindu-Arabic numerals is discussed and the pattern of identifying ones, tens, and hundreds digits within each period is pointed out. The film teacher stresses the fact that it is necessary to understand this pattern if a learner wishes to extend the system to name any whole number he so desires. The instructor adds that the young child must understand the fundamental concepts underlying "our" system of numeration before he learns to compute, otherwise he is likely to learn to compute mechanically with disastrous results in his subsequent work in mathematics.

At this point Professor Moray considers a typical student error in an addition situation, i.e., \(28 + 4 = 312\). He describes what the child must understand in order to avoid this type of mistake.

The last part of the filmed lesson summarizes the ideas previously presented, stresses those important features of "our" numeration system which the young child must be able to recognize and understand, and emphasizes the need for an understanding of the numeration system before investigating the computing algorithms.

Preview: Things to watch for in the film -

1) The pictured attempts of ancient man to develop techniques for treating numerical data.

2) The significant characteristics of the Egyptian, Roman, and Babylonian systems of numeration. Look for the features these systems have in common and those which distinguish between them.

3) The methods of counting and computing employed with the ancient systems of numeration. Note the different types of abacuses employed by people in different cultures.

4) The significant characteristics of the Hindu-Arabic numeration system.

5) The function of "periods" in "our" numeration system.

Postview: Be prepared to answer the following -

1) Explain why the development of a symbol for zero must precede the development of a numeration system exhibiting true positional notation?

2) What explanation do historians offer for the fact that most numeration systems have a base of ten?

3) Name at least one feature common to all four numeration systems discussed in the film. Compare and contrast the four types of numeration systems treated. Consider base, notation, ease of computation, etc.
4) Why do we call "our" systems of numeration the Hindu-Arabic system?

5) According to Professor Moray, why have numeration systems become more sophisticated over the ages?

6) Describe at least one way in which an elementary school teacher might employ different numeration systems to illuminate:
   a) the concept of the decimal aspects of "our" numeration system.
   b) the concept of positional notation.
   c) the notion that numbers and numerals are entirely different phenomena.

7) Explain why a youngster might write $28 + 14 = 312$ and identify the possible underlying misconceptions which could produce this type of error.
Film #3 - Addition and its Properties

This film, the third in the NCTM series, initiates the specific consideration of the four fundamental operations of arithmetic, i.e., addition, multiplication, subtraction, and division. Professor Moray's opening remarks focus attention on the need for understanding the nature of the operation addition as well as the proper interpretation of the plus sign before introducing the learner to addition computations. It is intimated that an individual who lacks such understanding generally becomes a "mechanical" computer and tends not to progress beyond the most elementary levels of mathematical achievement. To illustrate this situation, the film teacher exhibits a first-grade student's arithmetic paper containing the following exercise: \( 1 + 2 = 2 \). Parental questioning of the youngster revealed that the only significance attributed to the plus sign by the child was that "the teacher just puts it there." Apparently, the child associated no mathematical meaning with the symbol for addition. Professor Moray suggests that such situations are all too frequently encountered and that such situations tend to be eliminated if the learner has suitable preparation in attaching meaning to addition as an operation before he encounters addition as a computation.

Mr. Moray suggests that the concept of set can be employed to provide a meaningful approach to the concept of addition. It is noted that an understanding of addition rests upon two aspects of set theory, i.e., the child's ability to ascertain the number of elements in a given finite set and the process of joining sets (set union). Thus, the instructor of arithmetic may utilize the notion of set union to develop the concept of addition of whole numbers. In this film, Professor Moray carefully demonstrates one way in which this connection between set union and addition may be established. He also points out that the two joined sets cannot have elements in common if the cardinal numbers of the two sets are to yield the appropriate sum determined by the number of elements in the union of the two sets. In general, he asserts that addition is the assignment of a sum to a pair of addends.

The next portion of the film lesson introduces three important properties of addition, i.e., addition is commutative, addition is associative, and there exists an identity element for addition, namely, zero. In the first instance, the film teacher illustrates how a theoretical basis for commutativity may be established by utilizing the fact that set union is a commutative set operation. Subsequently, a series of classroom learning situations depict the ways in which "number blocks, number-line strips, and counting frames" may be used to develop the notion of commutativity. In particular, the viewer should note Professor Moray's remarks concerning the classroom use of the word commutative with very young children.

The film teacher treats the subject of associativity of addition in a similar manner. Situations involving numerals and sets of objects are employed to illustrate several ways in which the elementary school
teacher can focus attention on this useful and fundamental property of addition. The film teacher provides several examples of addition situations in which computations may be simplified and/or justified if the learner understands the associative property of addition.

The third property of addition is related to the notion of an identity element. Zero is seen as a special type of whole number since adding zero to any other whole number yields a sum equal to the whole number addend. This notion is also integrated into the theory of sets, specifically the concept of the null set. A classroom scene portrays one way in which a first-grade teacher may employ sets to convey the idea of zero as the identity element for addition. In this scene, the viewer should look for the following highlights:

1) First, note the general facility with the vocabulary of contemporary arithmetic which the first-grade pupils possess.

2) Second, note the deliberate manner in which the teacher "pours the contents of the two containers together" in order to provide a visual "joining" of the two sets.

3) Third, note the precise language employed by the teacher, e.g., "join the two sets, write the numeral on the board, two names for the same number," etc.

4) Fourth, it is interesting to note the rapport existing between the teacher and the class as evidenced by the parting remarks of the teacher and student after the student has completed his stint at the board.

The final portion of the film lesson is used to summarize the ideas introduced earlier in the lesson and to point out that the construction of addition tables can be utilized to help children recognize and understand patterns in the set of resulting sums which are due to the functioning of the commutative and associative properties of addition and the identity element for addition: zero. Is it suggested that the addition table can be used to initiate many open-ended investigations which, successfully pursued, may serve to produce additional and valuable learner insights.

Preview: Things to watch for in the film -

1) The method employed by the film teacher to relate the previously established ideas about sets to the new concept of addition.

2) The definitions of addition, sum, and addend.

3) The meaning of commutativity, associativity, and identity element with respect to the arithmetic operation addition.

4) The manner in which number-line strips, number blocks, and the counting frame may be employed to establish the idea of the commutative property of addition.
5) The manner in which sets of objects may be used to establish the idea of the associative property of addition.

6) The suggestions for employing the addition table to reinforce the ideas of associativity, commutativity, and identity element for addition.

Postview: Be prepared to answer the following -

1) Describe one way in which the concept of addition might be introduced as a number operation related to sets.

2) List three behavioral objectives a teacher might reasonably expect a first-grade pupil to achieve relative to the establishment of the concept of addition. Do the same for i) the commutative property of addition, ii) the associative property of addition, and iii) the identity element for addition: zero.

3) Describe two techniques a teacher might employ to demonstrate the necessity for non-overlapping sets when using set union to develop the concept of addition.

4) Given an addition table (zero through five), describe at least five patterns exhibited in such a table which a first or second grade youngster could reasonably be expected to identify.

5) List advantages and disadvantages you perceive in the approach to teaching "addition" recommended by Professor Moray.

6) What evidence do you find in the classroom scenes which tends to support or refute the contention that fundamental mathematical concepts can be understood and employed by very young children?

7) What understandings about sets must a child possess before sets may be used to develop the concept of addition? Why?

8) Should words such as commutative, associative, identity element, addend, sum, etc, be introduced in first or second grade? Why or why not? When should they be introduced?
The opening scene of this film is a view of a class of first-grade youngsters in the process of being introduced to the concept of multiplication by means of arrays. The action centers on the teacher who "flashes" a card exhibiting a three-by-two array. The children respond by calling out the number of points in the array. Subsequent questioning by the teacher reveals that different youngsters arrive at the correct answer, i.e., six, by different means. The viewer should look for the following items of interest in this scene:

1) First, note the speed with which the youngsters respond to the teacher's questions and the quick explanations provided by them in which they describe the manner in which they obtained the correct result.

2) Second, note the variety of viewpoints, i.e., the different ways in which the youngsters arrived at the total number of points in the array. List several of these avenues of thought below:
   a. 
   b. 
   c. 
   d. 

3) Third, note that one seemingly obvious way of "viewing" the array was NOT mentioned by any of the youngsters, and that during the second round of questioning this view was finally suggested by the teacher.

At the conclusion of this classroom scene, Professor Moray initiates an extended lecture-demonstration in which he presents five approaches to the concept of multiplication. These approaches are identified as "repeated addition, union of equivalent disjoint sets, number line, cross-product, and array." It is significant that each of these approaches is treated in a manner suitable for direct implementation in the elementary school classroom. Any one of the demonstrations performed by Professor Moray could form the basis for a bona fide second or third grade presentation.

1) **Repeated Addition**

   This approach is widely used and it is based on the child's ability to add and on his recognition of the peculiar situation involving a repeated addend, i.e., $2 + 2 + 2 = 6$. The learning objective focuses attention
on getting the child to accept $3 \times 2$ as a more economical way to identify $2 + 2 + 2$, or in effect, accepting the idea that $3 \times 2 = 6$.

ii) **Union of Equivalent Disjoint Sets**

This approach has the feature that it employs the concept of set, and it is closely related to repeated addition. It is generally thought to be somewhat less abstract than repeated addition since concrete and semi-concrete objects can be employed with this approach. The technique embodies the notion of joining, say, three sets of two objects and associating $3 \times 2$ with the number of elements in the union. The key idea is that the number of sets times the number of elements in one of the equivalent sets yields the desired product.

iii) **Number Line**

With this approach, the youngster observes equal "jumps" along the number line. The size of each "jump" is analogous to the reoccurring addend in repeated addition, while the number of jumps is related to the number of addends employed in a repeated addition situation. The objective is to get the child to realize that three jumps of two, i.e., $3 \times 2$, covers the same distance as one jump of six, therefore --- $3 \times 2 = 6$.

iv) **Cross-product**

This approach is a newcomer to the elementary school classroom, but it is rapidly being adopted because of its mathematical acceptability as well as its pedagogical utility. In this approach the cross-product of two sets is constructed and the number of elements in the cross-product represents the product of the numbers of elements in each of the two original sets. Professor Moray carefully points out the distinction between a product (a number) and a cross-product (a set of combinations).

v) **Array**

An array is described as a rectangular arrangement of points in which each row contains the same number of elements and each column contains the same number of objects. The number of objects in a row may differ from the number of objects in a column. The figure below is a three-by-two array. It is named in this manner because we usually name the number of rows first and the number of columns second.

```
*   *
*   *
*   *
```
Professor Moray describes how the array can be used to identify each of the situations described in i - iv above, and he states that because the array can be applied so generally, he will use it to define multiplication. He then defines multiplication as well as the terms factor and product. He then compares multiplication to addition in the sense that they both assign numbers to pairs of numbers.

The next portion of the film lesson deals with the properties of multiplication. The search for the properties of multiplication is motivated by the previous study of addition. The first property of addition, commutativity, raises the question of whether or not multiplication possesses a similar property. Consequently, an array is employed to demonstrate that $3 \times 4 = 4 \times 3$. It is noted that rotating an array $90^\circ$ reverses the order of the factors but leaves the total number of points in the array, i.e., the product, unchanged. Thus, we are led to believe that the operation multiplication possesses the property of commutativity.

The second property, associativity, is seemingly induced in the learner's mind through a series of computations which demonstrate that when three or more factors are multiplied, the order in which the multiplication takes place is immaterial.

Professor Moray continues to employ the analogy between the properties of addition and those of multiplication, and in so doing, he raises the question of a possible multiplicative identity element. He points out that children will discover, "if properly challenged," that this situation can be illustrated by a one-by-$N$ array, thus the identity element for multiplication is revealed to be the whole number --- one.

Professor Moray then raises the question: "Does zero play a special role in multiplication?" He states that the array fails to be an adequate device to illustrate the role of zero as a factor, and he suggests, instead, the notion of a cross-product as a vehicle to get across the idea that if $a \in \mathbb{W}$, then $a \times 0 = 0$ for all $a$.

The remainder of the film is a summary of the various points and ideas presented earlier in the lesson.

Preview: Things to watch for in the film -

1) The reactions and responses of the children in the initial classroom scene.

2) The discussions of the five approaches to multiplication:
   a) Repeated addition,
   b) Equivalent sets,
   c) Number line,
   d) Cross-product,
   e) Array.
3) The general applicability of the array to nearly all multiplication situations.

4) The notable failure of the array approach to lend itself to the development of one of the "properties of multiplication."

Postview: Be prepared to answer the following -

1) Should several different approaches to multiplication be employed in a given class or should a teacher select one of the approaches and employ it to the exclusion of the others? Why or why not? Give specific reasons for your position.

2) Consider each of the five approaches to multiplication presented by Professor Moray. List two strong points which you perceive in the utilization of each technique. Also, identify two weaknesses for each approach which should be considered whenever a given technique is to be employed.

3) What reasons are set forth by Professor Moray to justify his apparent preference for the array as an instructional visual-aid? The array, however, did not appear to be a suitable "approach" to one objective of the lesson. Which objective was it? Why was the array rejected? What approach was deemed suitable? Why do you think that the "approach" used was more satisfactory?

4) Do you think that the analogy drawn between the properties of addition and those of multiplication is an essential ingredient of the development of the concepts of addition and multiplication? Why or why not?

5) What possible weaknesses might be inherent in the technique of rotating an array to develop the idea of commutativity of multiplication? Explain.

6) Describe at least one way in which a teacher might supplement Professor Moray's treatment of the associative property of multiplication. Aim for some sort of demonstration which involves a less abstract approach than that depicted in the film.
Film #5 - Subtraction

This film opens with a classroom scene in which a group of primary-grade youngsters are attempting to discover the solution of the number sentence: \( 3 + \square = 5 \). In this scene, the viewer should note:

1) the manner in which the teacher questions the students and utilizes their responses to construct the number sentence \( 3 + \square = 5 \).

2) the young lad's explanation of how he used his fingers to obtain the correct result.

After the problem of finding a solution to \( 3 + \square = 5 \) is solved, Professor Moray presents a lecture-demonstration in which he introduces three approaches to subtraction. He calls the first of these the missing addend approach and he employs the number sentence \( 3 + \square = 5 \) to develop a subtraction interpretation for this obvious addition situation. It is suggested that for two important reasons this view of subtraction, i.e., the missing addend is equal to the sum minus the other or given addend, is the most important of the three views about to be considered. First, this approach focuses attention on the relationship between addition and subtraction, i.e., subtraction is the inverse operation of addition. Second, this approach provides a foundation which can easily be augmented to interpret more sophisticated mathematical situations, e.g., subtraction of negative numbers. Therefore, the sum minus the given addend is defined to be the missing addend, and the number \( 5 - 3 \) in the particular example under consideration is called the difference.

Professor Moray then suggests that there are a variety of ways in which children may utilize the notion of missing addend:

1) Fingers
   
   In simple problems, children may ask, "How many more fingers than three does it take to get five?" and then count to find this number after exhibiting the result with their fingers.

2) Number Blocks
   
   The question: "What goes with a 3-block to make a 5-block?" requires a search for a 2-block.

3) Guess and Check
   
   In this situation, the young student approaches the problem \( 2 + \square = 6 \) by guessing a number to fit the frame and then checks to see if he has a true number sentence. This particular example is tackled in a classroom shot by
a group of kindergarten or first-grade youngsters. The first guess is seven, but it is ruled out as "too big." The next guess is two, but it is ruled out as "too little." The third guess is four, and it checks. The viewer should note the manner in which the teacher encourages the children to suggest a possible solution and then gets them to analyze incorrect results in order to make more intelligent subsequent guesses. The film teacher strongly recommends this particular approach. He expresses the opinion that guessing and checking helps the child to think, figure out number relationships, and develop insight.

4) **Number Line**

The express $2 + \square = 6$ is represented on the number line by locating 2 on the line and then ascertaining the size of the jump necessary to reach six.

The second approach, take-away, is introduced via a classroom shot in which youngsters first view a set of five evergreen trees, see three of these trees chopped down, and face the problem of determining the number of trees remaining. This particular scene provides an excellent example of the way in which a teacher can introduce or develop an idea by asking questions and letting the learners provide all of the answers as they progress toward a solution to the problem.

After this classroom activity, Professor Moray returns to the lecture-demonstration. He partitions a set $C$ into two subsets $A$ and $B$ with the number of elements in each set represented by $c$, $a$, and $b$, respectively. He develops the following number sentences:

\[
\begin{align*}
\text{a} + \text{b} &= \text{c} \\
\text{a} &= \text{c} - \text{b} \\
\text{b} &= \text{c} - \text{a}
\end{align*}
\]

He points out that all three sentences are equivalent and that given any addition sentence of the type $a + b = c$, two subtraction sentences of the type indicated above can always be written. This general discussion is particularized with a specific numerical example.

The third approach, comparison of two sets, is illustrated by the number sentence $3 = 5 - \square$. This notion is introduced via a classroom shot in which youngsters are asked to find out how many cookies a person with five cookies must return to the cookie-jar in order to have the same number as another person possessing three cookies. The set of five cookies is compared to the set of three cookies by means of a one-to-one matching. The number of unmatched cookies represents the number of cookies to be surrendered. The number sentence $3 = 5 - \square$ is developed by the class.
At this point Professor Moray summarizes the three approaches as represented by the following number sentences:

\[ 3 + \square = 5, \quad \square = 5 - 3, \quad 3 = 5 - \square. \]

This discussion is followed by a classroom shot of third-graders involved in solving the following story problem:

Jim spent 98¢ for a pen and a notebook. The pen cost 79¢. How much did the notebook cost?

The viewer should note that when the children are requested to write a number sentence describing the problem, the form of each of the number sentences identified above is used by at least one youngster. Professor Moray then states that since the sentences are equivalent, the same computation can be used in each instance, i.e.,

\[ 98 - 79. \]

He points out that some of the children assumed subtraction to be commutative and in the process of using this idea they obtained an incorrect result. This leads to a discussion which reveals that subtraction is NOT commutative and NOT associative. It is also demonstrated that the addition sentence \( a + 0 = a \) yields two subtraction sentences, \( a - a = 0 \) and \( a - 0 = a \), which show that zero plays a unique role in subtraction, just as it did in addition and multiplication.

Finally, the film teacher compares the manner in which addition and subtraction assign numbers to number-pairs. The remainder of the film lesson is a summary of the ideas presented previously.

1) There are four separate classroom shots in this film. Note carefully the role of the teacher and the role of the pupils in each scene.

2) The explanation and interpretation of the sentences:
\[ 3 + \square = 5, \quad \square = 5 - 3, \quad 3 = 5 - \square. \]

3) The suggested teaching aids which might be useful in developing the concept of subtraction.

4) The discussion of the limitations of the "take-away" approach to subtraction.

5) The consideration of the possible commutativity and/or associativity of the operation subtraction.

6) The role of zero in subtraction.
Postview: Be prepared to answer the following -

1) Why is the "missing addend" approach thought to be the most important of the three approaches discussed in this lesson? Provide specific examples to support your argument.

2) When should subtraction be introduced into the elementary school curriculum? Should it be introduced after or along with addition? before or after multiplication?

3) One youngster who has appeared in several of the films appears to do nearly all of his computations on his fingers. Should this type of activity be permitted? Under what circumstances should this behavior be encouraged, ignored, discouraged?

4) Is guessing an answer really a mathematical approach to problem solving? Explain.

5) Given the number sentence $34 + 52 = 86$, write the two "subtraction sentences" associated with and equivalent to this "addition sentence."

6) Identify two (2) examples of problem situations which a teacher might employ when using the missing addend approach; the take-away approach; the comparison of sets approach. List problems other than those employed by Professor Moray.

7) Should a teacher employ all three approaches identified in the film? Explain.
Film #6 - Division

In this filmed lesson, Professor Moray describes several approaches which elementary school teachers might employ to develop the concept of division. Although he eventually makes it clear to the viewer that the most important idea about division is that it is the inverse of multiplication, he begins this lesson by stressing those interpretations of division which involve equivalent disjoint sets, the number line, repeated subtraction, and arrays. Each of the techniques is illustrated by a classroom teaching situation.

Equivalent disjoint sets

The opening scene of this film is a classroom shot of second grade children interpreting the division problem 12 ÷ 3. Professor Moray first solicits the children's help in writing the expression twelve divided by three as a number sentence on the chalkboard. He then produces a set of twelve balloons and proceeds to apportion them in subsets of three to several youngsters until he has no balloons left. After the balloons are distributed, he counts the number of children who have a set of three balloons in hand and determines the quotient: four. The viewer should note the following:

1) First, note that Professor Moray encourages the enthusiastic participation of the children by praising those who give correct responses to his questions.

2) Second, note that as the balloons are apportioned, they are counted out in unison by the rest of the class members.

3) Third, note that this scene provides an example of measurement division.

The Number Line

In this classroom sequence, a "beetle" named "Bouncy" habitually moves along the number line with jumps of equal length. The length of the jumps may vary from time to time, but in a given situation, the length of each of "Bouncy's" jumps remains some previously determined number of units. Professor Moray develops the notion of division (12 ÷ 3, again) by locating "Bouncy" at the point named twelve and asks, "How many jumps will it take 'Bouncy' to get back to the point zero if each jump has length three?" One youngster performs the task and determines the number of jumps required. The teacher explains that this is only one of several ways in which the number line may be employed to develop the notion of division. The viewer should note the following:

1) First, note the slight-of-hand maneuver on the part of the teacher to reverse "Bouncy's" direction and orient the insect toward zero.
2) Second, note the little girl's initial error when attempting to ascertain the number of jumps. Note her recovery, also.

Repeated Subtraction

In this classroom sequence the problem $12 \div 3$ is interpreted as the number of times three can be subtracted from twelve. The tiny female "star" of this scene demonstrates conclusively the manner in which the quotient, four, is obtained. The professor states that this notion is an acceptable introductory objective, but that it has limited value as a singular method of instruction. Consequently, it only has value when used in conjunction with other approaches to division.

Rectangular Array

This classroom shot demonstrates one way in which the array may be used to develop the concept of division. The teacher exposes the top row of a partially concealed array. The youngsters are asked to state the number of columns in the array by examining the elements in the revealed row. Then the total number of elements in the array is stated by the teacher and the students are requested to determine the number of rows in the array. Subsequently, the number of elements divided by the number of columns is defined to be the number of rows.

At this point, Professor Moray summarizes the four approaches described above and he states that all four views could be employed to illustrate the inverse relationship between multiplication and division. The point was made that it is essential to have this particular relationship recognized and understood by the learner.

Professor Moray uses the expression $4 \times 3 = 12$ to explain the terms factor and product. He then shows how $3 \times \square = 12$ can be interpreted as a division situation and defines the missing factor as $12 \div 3 = \square$. He calls the number sentence $12 \div 3 = \square$ a quotient expression. He makes the point that every multiplication number sentence (except certain sentences involving zero) will yield a pair of equivalent division number-sentences, i.e., $4 \times 3 = 12$ yields the sentences $12 \div 3 = 4$ and $12 \div 4 = 3$.

All of this is followed by a claim that $12 \div 3$, $\frac{12}{3}$ and $3\sqrt{12}$ are all names for the same number.

Next, Professor Moray describes three "different" ways in which fourth grade students used the "missing factor" approach to answer the question: "If 192 chairs are arranged in 12 rows, with each row containing the same number of chairs, how many chairs will there be in each row?" Students produced the following number sentences:

$$12n = 192$$
$$n = 192 \div 12$$
$$192 \div n = 12$$

Interpretations of these number sentences are then considered.
The next area of concern focuses attention on the properties of division. Numerical examples are used to show that division is NOT commutative and that it is NOT associative. The role of zero in division is also discussed and the following division situations involving zero are specifically considered:

\[ 0 \div n \quad n \div 0 \quad 0 \div 0 \]  

(where \( n \) is some nonzero whole number)

To facilitate the development of the concept of division when zero is involved, Professor Moray states that in a division situation, e.g., \( 6 \div 2 = \square \), two requirements must be met. First, the quotient expression, i.e., \( 6 \div 2 \), must name some number, and second, the quotient expression must name only one number. Employing these requirements and the multiplication-division inverse relationship, he proceeds to show that \( 0 \div n = 0 \) while \( n \div 0 \) and \( 0 \div 0 \) are both meaningless.

Finally, the role of 1 in division is considered. The topic is introduced by recalling that \( axl = a \) and that every multiplication number-sentence yields two division sentences (providing \( a \neq 0 \)), thus \( axl = a \) yields the sentences:

\[ a \div 1 = a \quad \text{and} \quad a \div a = 1 \]

The remaining film time is used to summarize the ideas presented earlier in the lesson.

**Preview:** Things to watch for in the film -

1) There are several classroom shots in this film. Watch for the various ways in which students actively participate in the ongoing learning situation.

2) The descriptions of the four approaches to division, i.e., equivalent disjoint sets, the number line, repeated subtraction, and arrays.

3) Observe the little girl who works with "Bouncy."

4) The emphasis placed on the interpretation of division as the inverse of multiplication.

5) The techniques employed to demonstrate that \( 0 \div n = 0 \) and that \( 0 \div 0 \) and \( n \div 0 \) are meaningless. Note role of definition of division.

6) The specific requirements necessary to give meaning to the expression \( 6 \div 2 \).

**Postview:** Be prepared to answer the following -

1) Prove that \( 0 \div 0 \) and \( n \div 0 \) are meaningless in our arithmetic. In each case, what specific requirement fails to be met?
2) Why do you suppose that Professor Moray felt the need to exchange one "beetle" for another in the "Bouncy" episode? Provide an explanation for the little girl's initial error in moving "Bouncy."

3) Is it important for a young learner to realize that division is not commutative? Associative? Why or why not? What type of student errors might be expected in arithmetic situations if pupils are confused about either of these ideas?

4) Compare the equivalent-disjoint sets approach to the repeated addition approach. How do they differ? How are they alike? Describe a learning situation involving "concrete objects" to illustrate each type.

5) Describe one way in which the array could be used to develop the concept of division as the inverse operation of multiplication. Be specific.

6) Classify each of the four approaches described in the film as measurement or partition division.
A previous film, film #3, developed several of the fundamental ideas which many mathematics educators believe must be established before children can be said to understand the concept of addition. This film, on the other hand, focuses attention on some of the techniques employed to rename numbers. Professor Moray points out that when we ask a student to find the sum of seventeen and fifteen, the response 17 + 15 is both reasonable and accurate. However, when we pose such a question we actually want the youngster to compute the sum of these two numbers, i.e., we want him to find the standard name for the sum of seventeen and fifteen, or 32. This process of finding a new name (usually the standard name) for a number is called an algorithm. An algorithm, then, is a step-by-step procedure for renaming a number. Thus, when we talk about computing, we are generally talking about algorithms.

Professor Moray follows this introduction with a lecture-demonstration which highlights three algorithms for addition. The first of these strategies utilizes expanded notation:

\[
17 = 10 + 7 \\
+15 = 10 + 5 \\
\underline{20 + 12} = 10 + (10 + 2) = (20 + 10) + 2 = 30 + 2 = 32.
\]

This method is related to the joining of sets and it emphasizes grouping by tens. It also employs the associative principle of addition.

The second algorithm employs separate sums:

\[
17 \\
+15 \\
\underline{12} \\
20 \\
\underline{32}
\]

This method is somewhat shorter than the first and it also permits the learner to work with the tens and ones separately.

The third algorithm is the traditional algorithm for addition which utilizes mental manipulations to reduce written work. It is agreed that this procedure is the most efficient, but it is also recognized that this method contributes very little to the understanding of the student. It is quite possible that if this short-form technique is introduced too early in a mathematics program, the algorithm will be learned mechanically and without knowing why the manipulations produce the correct result.
Professor Moray follows the presentation of the three addition algorithms with a consideration of two subtraction algorithms. The first subtraction algorithm involves both regrouping and expanded notation:

\[
\begin{align*}
42 &= 30 + 12 \\
-28 &= 20 + 8 \\
10 + 4 &= 14
\end{align*}
\]

The second method involves equal additions. This strategy is based on the fact that when the same number is added to both the sum (minuend) and the given addend (subtrahend), then the missing addend (remainder) is the same as it was before the additions took place. It is also noted that this algorithm depends upon the way in which the equal additions are performed, i.e., ten ones are added to the sum (minuend) while one ten is added to the given addend (subtrahend).

At this point in the film, the format changes to a series of classroom situations which illustrate the utilization of these algorithms by second and third grade students. The first such scene portrays a second grade youngster using concrete objects (sticks) to determine the standard name for 17 + 15. After demonstrating one way in which the sticks may be regrouped to identify thirty-two, the student describes the associated number story on the chalkboard in terms of expanded notation. Professor Moray states that this technique serves to clarify the role of base-ten in the algorithm.

The next scene depicts a student using the separate sums algorithm to determine the standard name for 28 + 35. This method is said to avoid regrouping while simultaneously permitting the learner to concentrate on column addition.

The third observation reveals how a youngster employs and describes the traditional algorithm for addition. The significant difference between this technique and the previous ones is the increased amount of mental manipulation with a corresponding decrease in the amount of recorded data.

In the next scene a second grade girl describes "her personal method" of adding four numbers. Professor Moray questions her about the validity of certain procedures she employed and the young lady explains precisely how the commutative and associative properties of addition can be used to justify each step of her algorithm. Note especially, the poise of the student, the apparent depth of her understanding, her ability to write and talk simultaneously (a feat many student-teachers find quite difficult to master), and the detailed nature of her explanation. The point is made by the film teacher that an understanding of the properties of addition provides a basis for creative work in mathematics and it enables a child to invent algorithms of their own.

The fifth classroom shot is one in which a second grade boy employs expanded notation to find the difference of 42 and 28. After
illustrating the expanded notation technique, the student demonstrates a short method of subtracting which he has discovered. The significance of this achievement is not that he has produced the traditional algorithm for subtraction but that he arrived at the most efficient method of subtracting two numbers without sacrificing understanding. Note the young man's reason for preferring the traditional algorithm.

The final scene provides an opportunity for a sixth grade boy to explain a peculiar method of subtraction which he has devised. Again, the significant aspect in this situation is the fact that the youngster understands exactly why the algorithm works. When questioned about details, he can provide precise explanations! Note his justification for adding the same quantity to both numbers and his appropriate use of the terms "sum" and "addend."

Professor Moray's closing statement identifies the point that since algorithms tend to be quite mechanical, it is quite possible for youngsters to learn them by memorizing certain facts and certain rules, but when the learning of an algorithm is not accompanied by understanding, the student's mathematical development may be severely curtailed. Students who learn only the how of an algorithm are generally handicapped in the later stages of their mathematical development.

Preview: Things to watch for in the film -

1) Professor Moray's descriptions of the three addition algorithms and the two subtraction algorithms prior to the classroom scenes.

2) The definition of an algorithm.

3) The presentation by the second grade girl which deals with how and why she can change the order of the addends.

4) The sixth-grade boy's explanation of "his" equal-additions subtraction algorithm.

5) Professor Moray's behavior in each classroom scene when the students are demonstrating particular algorithms at the chalkboard.

6) The vocabulary employed by each of the students when he (or she) explains his (or her) algorithm.

Postview: Be prepared to answer the following -

1) Do the students provide convincing arguments when questioned about their work? How would you explain such behavior? Do you think the students are play-acting or do you believe that these demonstrations are bona fide teacher-student interactions?
2) What was Bruce's reason for preferring the traditional subtraction algorithm rather than the expanded notation technique? What does his response indicate with respect to the need to begin the study of algorithms by introducing the most efficient ones first?

3) Describe Professor Moray's activities while students are providing explanations at the chalkboard. What is your opinion of his behavior? Give reasons to support your contention.

4) In your opinion, which student activities portrayed in the film were most impressive? What conclusions might you draw from these observations? Explain.

5) Describe one addition algorithm and one subtraction algorithm different from those presented in the film. Preferably these should be strategies of your own invention.

6) List at least two reasons which might justify the use of the addition algorithm which employed expanded notation.

7) State the chronological order in which the three addition algorithms described in the film should probably be introduced. Explain why you believe your stated sequence seems to be the most reasonable order of introduction to you.
Film #8 - Multiplication Algorithms and the Distributive Property

The opening scene of this film portrays a group of elementary school teachers participating in an in-service meeting apparently organized to discuss arithmetic teaching. The meeting is conducted by Professor Moray. At the end of the meeting, one of the teachers (Mrs. Carole Casper) requests some suggestions for the introduction of the multiplication of two numbers when at least one of the factors is greater than ten. Professor Moray suggests that the students should be presented with a multiplication problem which is novel for them, i.e., something like $6 \times 14$, and then the children should be encouraged to discover possible multiplication algorithms. The teacher who raised the question subsequently follows his suggestion precisely. One child immediately proposes a possible method by suggesting that fourteen should be used as an addend six times. The teacher accepts this suggestion, but she restates the problem and asks the youngsters to think of other strategies which employ only multiplication.

The next scene finds one of the class members (Wendy) arriving home. Her father is washing the family automobile and invites her to help him with his task. After declining his invitation because she has "homework" and after explaining the nature of her assignment, the father suggests that she try to recall some past experiences in arithmetic which might give her a clue to a method of solving this particular problem. In a "dream sequence," Wendy recalls that earlier, in class, she solved the problem of $4 \times 7$ by splitting seven and renaming it as $5 + 2$, i.e., $4(7) = 4(5 + 2) = 4 \times 5 + 4 \times 2 = 20 + 8 = 28$. She then applies this same technique to the problem of $6 \times 14$. In this way she decides that $6(14) = 6(10 + 4) = 6 \times 10 + 6 \times 4 = 60 + 24 = 84$.

The next film shot is a view of the next weekly meeting of the teacher group and the manner which Wendy solved the problem is described by Mrs. Casper. Professor Moray explains that Wendy's method is actually an application of the distributive property, and he demonstrates how the property can be applied in the general situation. In this presentation, he employs the concept of an array to illustrate the manner of "splitting" one of the factors. He concludes that: "For any three whole numbers, $a$, $b$, and $c$, the expression $a(b + c)$ is always equal to the expression $ab + ac$. He makes the point that children should understand the distributive property before they are introduced to multiplication computation. He supports this contention by demonstrating the way in which a youngster might fail to understand what he is doing when he employs the usual multiplication algorithm.

At this point a film is used to show the teacher group how an array could be employed to demonstrate the role of the distributive property in the traditional multiplication algorithm. The moderator of this film-within-a-film states that fourteen can be "split" in a variety of ways, e.g., $9 + 5$, $8 + 6$, etc., but that we generally utilize the decimal aspect of the numeration system by splitting fourteen into $10 + 4$. Three algorithms for multiplying $6 \times 14$ are then described:
The use of the distributive property is then extended to compute the product of 13 and 24, and the three forms of multiplication algorithms just described are again illustrated.

1) \[ 13 \times 24 = (10+3) \times (20+4) = (10 \times 20 + 3 \times 20) + (10 \times 4 + 3 \times 4) = (200 + 60) + (40 + 12) = 312. \]

2) \[
\begin{array}{c}
24 \\
\times 13 \\
12 \\
60 \\
40 \\
200 \\
312
\end{array}
\]

3) \[
\begin{array}{c}
24 \\
\times 13 \\
72 \\
240 \\
312
\end{array}
\]
1) One teacher suggests that the basic idea of the distributive property can and should be introduced very early in the curriculum.

2) A second teacher expresses the idea that children should be permitted to discover algorithms whenever possible.

3) A third states that it is important to explicitly check for understanding and not assume that when a child obtains the correct result, it implies that understanding took place.

The discussion which produced these comments by the teachers also served to terminate the film.

Preview: Things to watch for in the film -

1) The mention of the understandings which necessarily must precede the expectation that children can "figure out" algorithms.

2) The presentation by Professor Moray in which he uses an array to analyze the distributive property.

3) The film-with-a-film sequence which illustrates the manner in which partitioned arrays can be used as models to illuminate the distributive property. In particular, note the introduction of the terms partition and partial products.

4) Note the ordered sequence of the algorithms for multiplication.

Postview: Be prepared to answer the following -

1) What is the difference between, one, explicitly telling a student what the "correct" algorithm is, and, two, encouraging a student to suggest possible algorithms and reject all proposals except the "correct" one? Is the learning situation different from the two approaches? Explain.

2) What background information must a youngster possess before we can reasonably expect him to develop multiplication algorithms of his own invention?

3) Describe the sequential order of presentation for the three multiplication algorithms mentioned in this lesson. Justify the sequence you have described. Give specific reasons.

4) Use an array to illustrate the product of 5 and 16; 14 and 28. Employ techniques similar to those used in the film.

5) Write a detailed (step-by-step) account of the manner in which you would use the abbreviated multiplication algorithm to compute the product 7 x 36. Assume a student has computed
(or is in the process of computing) $7 \times 36$. Prepare five
penetrating questions which you might ask this student in
order to assure yourself that he understood (understands)
precisely what he was (is) doing at various points in the
computation procedure.
Film #9 - Division Algorithms

The opening scene in this film is a camera shot in a second grade classroom. In this segment, Professor Moray describes a situation in which a young man who owns a piggy bank, containing pennies, decides to empty the bank and count the number of coins he has saved. The owner of the bank discovers that he has five hundred fifteen pennies. Furthermore, he decides to collect nickels rather than pennies and he is interested in finding out the number of nickels he would receive in exchange for the pennies. At this point, the film teacher poses the following questions for student consideration: "How many nickels would he get for five hundred fifteen pennies? How would you figure it out?" One young lady suggests that it would be necessary to divide and, at the teacher's suggestion, she writes \( \frac{5}{515} \) on the chalkboard. The teacher then requests each youngster to copy the problem on their paper and find out the desired number of nickels.

In the next scene, Professor Moray analyzes a computational error which appeared on several papers, i.e., 515 divided by 5 is equal to 13. He stated that one of the youngsters who got this particular result seemed to be quite satisfied with the result as it stood, even though attempts were made to focus his attention on the error. Another student, however, immediately recognized the unreasonable nature of 13 as the quotient when she was asked to explain her method of obtaining the answer. Professor Moray suggests that the most likely cause of such errors is due to the fact that the students had been "introduced to a formal computation procedure too soon." He also states that when abbreviated algorithms are introduced too early, the algorithms are seldom accompanied by understanding. He suggests that one sound way in which to develop an understanding of computational procedures is to help children work out their "own" algorithms.

This point, i.e., developing personalized algorithms, is then illustrated by a problem similar to the "piggy bank problem," except that in this instance we wish to convert 65 pennies to nickels. The first illustrated attempt to compute a quotient utilizes repeated subtraction, but Professor Moray feels that the extreme length of this procedure motivates youngsters to seek a more acceptable computational technique. He thinks that some youngsters will suggest "removing" multiples of five to speed up the procedure and that this idea is a major step toward developing a suitable division algorithm.

<table>
<thead>
<tr>
<th>Repeated Subtraction</th>
<th>Subtracting Multiples of 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>-5</td>
<td>-50 = 10 \times 5</td>
</tr>
<tr>
<td>60</td>
<td>15</td>
</tr>
<tr>
<td>-5</td>
<td>-15 = 3 \times 5</td>
</tr>
<tr>
<td>55</td>
<td>0</td>
</tr>
<tr>
<td>-5</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td></td>
</tr>
</tbody>
</table>
When the latter technique is written in the horizontal form, the presence and role of the distributive property are clearly indicated:

\[ 65 = 50 + 15 = 10 \times 5 + 3 \times 5 = (10 + 3) \times 5 \]

The ten and the three are referred to as partial quotients.

Another approach to division employs the array and "the" division algorithm to interpret a quotient and remainder. The question, "How many threes in fourteen?" followed by a directive to construct an array of fourteen points with three points in each row is used to initiate the consideration of the desired concepts. The resulting "array" has four rows of three elements and one row containing only two elements, hence it is considered to be a four-by-three array with an excess of two elements. The number of rows is called the quotient and the number of elements in the incomplete row is called the remainder. In this particular example, the quotient is four and the remainder is two.

The next step in this procedure introduces student consideration of equations of the form \((\square \times 5) + \triangle = 17\). Methods of handling these types of equations in a third grade class are then demonstrated. As the scene opens, the class is just finishing the task of finding all possible pairs of whole numbers which make the statement \((\square \times 5) + \triangle = 17\) a true statement, i.e.,

<table>
<thead>
<tr>
<th>(\square)</th>
<th>(\triangle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

This achievement is followed by a similar consideration of the expression \((\square \times 4) + \triangle = 27\) with the additional requirement that only the greatest possible number for the \(\square\) will be accepted. One youngster first tries 5 and 7, but eventually, with a little coaxing, produces the desired result, 6 and 3. This result is checked. Then a more difficult problem, \((\square \times 3) + \triangle = 65\), is attempted. No immediate suggestions were made by the students. Finally, one girl proposes "doing it by parts." "Doing it by parts" turns out to be the subtraction of 10 threes first and the subtraction of 11 threes second. The student then proceeds to write out the correct pair of numbers, i.e., 21 and 2. Professor Moray questions the student about the reasons for the different steps in the process. He then provides an analysis of the activities just observed.

Following this analysis, Professor Moray explains the relationship between the missing factor type of number sentence \((65 = \square \times 5)\) and its equivalent quotient expression \((65 \div 5 = \square)\). He relates the terms product \((65)\), given factor \((5)\), and missing factor \((\square)\) to the typically employed terms dividend, divisor, and quotient. He also describes the
manner in which the algorithm involving the removal of multiples of powers of ten can be slightly modified to provide an example of the type of algorithm used in many elementary arithmetic textbooks employed today.

The next scene demonstrates how a sixth grade student utilizes this algorithm (subtracting multiples of powers of ten) to find the quotient: $6475 \div 27$. Pay particularly close attention to the explanation provided by the student as he solves the problem. Professor Moray then discusses three division algorithms:

<table>
<thead>
<tr>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td>27/6475</td>
<td></td>
<td>239</td>
</tr>
<tr>
<td>5400</td>
<td>200</td>
<td>30</td>
</tr>
<tr>
<td>1075</td>
<td>200</td>
<td>54</td>
</tr>
<tr>
<td>310</td>
<td>30</td>
<td>107</td>
</tr>
<tr>
<td>265</td>
<td>27/6475</td>
<td>81</td>
</tr>
<tr>
<td>243</td>
<td>9</td>
<td>265</td>
</tr>
<tr>
<td>22</td>
<td>810</td>
<td>243</td>
</tr>
<tr>
<td></td>
<td>239</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>264</td>
<td></td>
</tr>
<tr>
<td></td>
<td>243</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>

He points out that the different algorithms require different degrees of estimating ability on the part of the students when they are in the process of selecting partial quotients. Furthermore, he feels that Type III tends to be learned mechanically and in many cases the student fails to understand that the "54" really identifies 5400 in that "bringing down the 7" is, in fact adding 70 to 1000, etc.

Professor Moray states that one reason that the division algorithm has been so troublesome to teach in the past is probably due to the fact that the abbreviated algorithm was introduced too soon. The result was that children had great difficulty in understanding how each step was related to finding the quotient. Currently, he says, the tendency is to introduce a more easily understood algorithm, e.g., Type I above, and then to allow children to use that procedure as long as they find it necessary. The more able students can learn shortened algorithms, but most children do not seem to benefit from the use of abbreviated algorithms until late in the elementary school.

In summary, the following ideas are mentioned:

1) Children should be given opportunities to make up their own algorithms, e.g., they can use repeated subtraction.

2) Second, the procedure of repeated subtraction can be condensed to use multiples of powers of ten as partial quotients.

3) Expressions of the type, $65 = (\Box \times 3) + \triangle$, can serve as a basis for developing division algorithms.
4) Any algorithm employed by a child should be one he understands thoroughly.

Preview: Things to watch for in the film -

1) The discussion of the two possible reasons underlying the error \( 515 \div 5 = 13 \).

2) The description of the three general categories of division algorithms, i.e., repeated subtraction, subtraction of multiples of powers of ten, abbreviated (traditional) algorithm.

3) The identification of the properties of operations and numbers which justify the step-by-step procedures comprising the algorithms.

4) The use of "the" division algorithm to introduce the concept of remainder.

5) The presentation relating the terms missing factor, given factor, and product to the terms quotient, divisor, and dividend.

6) The sixth grade students' explanation of the algorithm he employed to divide 6457 by 27.

7) The reasons set forth by Professor Moray as causes of the difficulties encountered in previous attempts to teach the abbreviated division algorithm.

8) The summarizing statement at the end of the film which explicitly identifies the main points in the film lesson.

Postview: Be prepared to answer the following -

1) According to Professor Moray, why have youngsters experienced difficulty in "learning division" in the past? What does he suggest to improve this situation? What is your opinion of his suggestion? What other reasons might you suggest to explain the apparent difficulty in learning division algorithms when compared with the learning of algorithms for addition, subtraction, or multiplication?

2) If a student divides 515 by 5 and obtains a quotient of 13, what possible misconceptions might he possess? Identify at least three possibilities.

3) Describe one way in which a teacher might direct a student from the utilization of an unadulterated "repeated-subtraction" algorithm to the abbreviated version of the division algorithm. Specify the concepts and understanding you feel
must be established at each level of achievement before progressing to the next plateau. What sort of timetable would you suggest for this transition?

4) Professor Moray suggests that the present tendency is to introduce a more easily understood division algorithm and permit the student to use if "as long as he needs to." What do you think he means by "as long as he needs to?" Do you agree with this assertion? Explain why or why not.

5) What problems are confronted in estimating partial quotients in each of the three categories of algorithms? (see Preview #2 above). Which type of algorithm encompasses the most rigid form of partial quotient estimation? Is any one type of algorithm foolproof with respect to estimating partial quotients? Explain your reply.
The introductory portion of this tenth and final film in this series describes some of the historically important functions and uses of mathematics. Professor Horay asserts that since the beginning of recorded history, mathematics has played a role in the growth of civilization. The ancient Egyptians, for example, found a knowledge of mathematics to be useful in agriculture, commerce, and architecture. The early Greeks incorporated mathematical reasoning as an important ingredient in their culture, and they established the foundations for later developments in the field of mathematics. Mathematics played a vital role in the development of science and industry since the advent of the Renaissance. Today, the accelerated developments occurring in science, industry, and society demand related adjustments in mathematics. The mathematics curriculum has changed to meet modern needs. More mathematics is being taught sooner and in greater depth. It is asserted that since mathematics is a part of every child's education, he has a right to be taught mathematics so he can understand it, and he deserves the chance to like mathematics.

Professor Horay says that the sequential and cumulative nature of mathematics suggests that the type of mathematics taught in the elementary school is of crucial importance to the overall mathematical development of the individual. He states that appropriate curriculum materials are available for all grade levels and that the job of the teacher is to adapt these materials to the individuals in the classroom. In particular, he feels that, as teachers, we must establish "key mathematical ideas." The specific ideas he mentions are mainly associated with the set of whole numbers and include: set, number (numerals), operations (properties of operations), order, and proof. He claims that the importance of these ideas is attested to by the manner in which these concepts contribute to the child's understanding of the nature and function of mathematics.

According to Professor Horay, it is difficult to isolate any one of these ideas for consideration because they are all so closely related. Any discussion of one of these ideas immediately touches on one or more of the others. Referring to the previous filmed lessons, he illustrates this point by relating that the concept of set was first used to develop the notion of a one-to-one correspondence which, in turn, was employed to distinguish between equivalent and nonequivalent sets. Subsequently, the concept of a whole number was based upon equivalent sets and number was considered to be a property of sets. In addition, the ordering of sets was related to the ordering of numbers and this, in turn, led to the ideas of "less than" and "greater than." Numbers were then used as the basic elements of a mathematical system, i.e., the system of whole numbers. Sets were used to define the sum of two numbers, the cross-product of two sets was used to define the product of two numbers, the partitioning of sets was used to define the difference of two numbers, and the partitioning of a set into equivalent, disjoint subsets was used to define the quotient of two numbers.
The definitions of sum and product led to the concept of operation which was considered to be a set of assignments, e.g., addition assigns the sum $2 + 3$ or $5$ to the pair of numbers $(2, 3)$. Professor Horay then discusses the analogous roles of multiplication, subtraction, and division. He points out that addition and multiplication are the fundamental operations from which subtraction and division may be derived.

The nature of unary operations is contrasted with that of the binary operations of addition and multiplication. Professor Horay uses the process of "squaring" a number as an example of a unary operation since it assigns a particular whole number to each individual element of the set of whole numbers.

The properties of addition and multiplication, i.e., commutativity, associativity, and their respective identity elements are then reviewed by Professor Horay. The distributive property, which involves both fundamental operations, is briefly considered. The point is made that a knowledge of these fundamental properties is important to the establishment of understandings of subsequent computational procedures. He claims that once these key ideas are clearly understood, children can put them to work in mathematical sentences to help them solve problems.

In the discussion that follows, Professor Horay outlines a general procedure for solving verbal or word problems:

1) The verbal problem is translated into a mathematical sentence.

2) The operation involved is determined.

3) A renaming or computation process is used to find the standard name for the desired number.

4) The interpretation of the solution is related back to the original verbal problem.

The terms open sentence, solution, and solution set are also explained in this presentation.

The next portion of the film provides a brief consideration of the extension of the whole number system to the system of integers and thence to the system of rational numbers. The main thought presented here is that an understanding of the key ideas of the system of whole numbers facilitates the child's understanding of integers and rational numbers because of the relationships existing between and among these number systems. He states that the real power of mathematics lies in the fact that so many useful ideas can be derived logically from a relatively small number of basic ideas. He believes that the child cannot develop a feeling for this aspect of mathematics unless he understands the basic ideas first.
The final topic considered by Professor Moray is a short description of mathematical proof. By way of illustration, a classroom scene involving sixth grade students is used to demonstrate how these youngsters go about proving that the sum of two even numbers is always an even number. In this sequence, the role of definitions and the basic properties of numbers are highlighted. It is suggested that proofs are founded on previously established key ideas of mathematics.

In a summarizing statement, Professor Moray points out that mathematics has an ever increasing influence on modern civilization. He suggests that it is interesting to speculate on the probably role of mathematics twenty or thirty years from now. He states that we, as teachers, can make a real contribution to the next generation by helping today's children understand the key ideas of mathematics.

Preview: Things to watch for in the film -

1) The role of the concept of set in developing some of the key ideas of mathematics.

2) The identification of the five "key ideas" suggested by Professor Moray.

3) The description of an operation and the comparison of unary and binary operations.

4) The suggested general procedure for solving verbal or word problems.

5) The definitions of open sentence, solution, and solution set.

6) The manner in which the key ideas underlying the system of whole numbers can be employed to understand the system of integers and the system of rational numbers.

7) The classroom scene in which sixth grade students prove that the sum of two even numbers is always an even number.

Postview: Be prepared to answer the following -

1) Describe several ways in which the concept of set is employed to illuminate key mathematical ideas.

2) What is a mathematical operation? Are subtraction and division operations? Why or why not?

3) What is your opinion of the general procedure for solving word problems outlined by Professor Moray? Which steps do you suspect will generate the most difficult teaching situations? Explain.
4) Define the term open sentence! solution! Provide an example of an open sentence. Find and exhibit its solution set. What specific information (other than the open sentence, itself) must be given to or assumed by the problem solver in order to ascertain the solution set?

5) Do you think that the arguments set forth by Professor Moray to justify the new mathematics curricula are convincing? Why or why not?

6) List five reasons for including mathematics in the elementary school curriculum. List five reasons for excluding it from the curriculum.

7) In discussing the use of sets to define difference and quotient, Professor Moray also employs the term partitioning. Does he use the term in the same sense in both instances? Explain.
APPENDIX C

Measurement Instruments
CEAS SCALE INSTRUCTIONS

This scale is designed to measure your ability to detect computational errors and to estimate adequate possible causes of these miscalculations. Each item in the scale presents a simple student computation (shown in red, see example #0 below). Each item also presents four hypotheses which a teacher might formulate to pinpoint the cause of the error and to help define the nature and extent of appropriate remedial instruction.

Each person completing this scale should read the statement of the problem, study the given computation, and ascertain the computational error. Then, he should select the "BEST" of the four suggested hypotheses and write the letter preceding his choice in the appropriate space on the response sheet. The "BEST" hypothesis is the one which is most relevant to the computational error under consideration and, at the same time, the one which identifies the mathematical concept which is most likely to encompass the actual misconception possessed by the student. In order to make this idea clear, we will consider the following example in detail:

#0. A student was requested to rename \( \frac{1}{2}, \frac{2}{3}, \frac{3}{4} \) by utilizing a least common denominator. The student's work is shown below:

\[
\frac{1}{2} = \frac{1 \times 2}{2 \times 1 \times 2} = \frac{2}{2 \times 1 \times 4} = \frac{12}{24} \quad \frac{2}{3} = \frac{2 \times 8}{3 \times 8} = \frac{16}{24} \quad \frac{3}{4} = \frac{3 \times 6}{4 \times 6} = \frac{18}{24}
\]

An analysis of these data leads one to believe that the student:

a) does not know how to compute equivalent fractions.
b) does not understand the concept of least common multiple.
c) does not understand the concept of least common denominator.
d) does not understand that within the set of rational numbers, multiplication distributes over addition.
ANALYSIS OF EXAMPLE #0:

Choice (a) is false because the student has in fact produced three pairs of equivalent fractions, i.e., \( \frac{1}{2} = \frac{12}{24} \), \( \frac{2}{3} = \frac{16}{24} \), and \( \frac{3}{4} = \frac{18}{24} \). Therefore, we reject choice (a) because it is contrary to the evidence presented in the given computation.

Hypothesis (c) appears to be the obvious "BEST" choice, because the student did fail to produce the least common denominator. However, hypothesis (b) introduces the more inclusive concept of least common multiple, i.e., least common denominators are particular cases of least common multiples. It would seem, then, that (b) is a better choice than (c).

Finally, (d) directs our attention to the distributive principle, but since the computation under consideration provides absolutely no information relative to the youngster's knowledge of this principle, we must consider the statement irrelevant and judge it to be something less than the "BEST."

The hypothesis which appears to be the "BEST" of the four in this particular case is (b) because it focuses directly on the error involved, yet, it is broad enough to include the most probably cause of the computational error.

DIRECTIONS: Read each of the following items carefully. Study the given computation and decide what type of error the student made in his calculation. Then select the "BEST" of the four hypotheses and write the letter preceding your choice in the appropriate blank space on the response sheet.

PLEASE RESPOND TO EVERY ITEM ON THE SCALE. THERE IS NO SPECIFIED TIME LIMIT FOR COMPLETING THE SCALE SO USE WHATEVER TIME YOU FEEL YOU NEED.
1. A second grade student renamed $12 + 46$ in the following manner:

\[
\begin{array}{c}
12 \\
+ 46 \\
\hline
85
\end{array}
\]

An analysis of these data leads one to believe that the student:

a) does not understand the "decimal (base ten) aspect" of our numeration system.
b) found the sum of two units and six units and placed it in the "tens" column.
c) does not understand the concept of "place value."
d) does not know the basic addition facts.

2. A third grade student renames $823 \times 4$ in the following manner:

\[
\begin{array}{c}
823 \\
\times 4 \\
\hline
32812
\end{array}
\]

An analysis of these data leads one to believe that the student:

a) does not understand regrouping.
b) does not know the basic multiplication facts.
c) does not understand the difference between a "number" and a "numeral."
d) does not understand the concept of "place value."

3. A first grade student named the number of tally marks shown below in the following manner:

```
/ / ( / / / / / / ) ( / / / / / / )
```

An analysis of these data leads one to believe that the student:

a) does not understand the commutative property of addition of natural numbers.
b) does not understand the concept of "place value."
c) does not understand the nature of a two-digit numeral.
d) does not understand the "decimal (base ten) aspect" of our system of numeration.
4. A sixth grade student renamed \(2 \frac{1}{3} : 2 \frac{2}{5}\) in the following way:

\[
2 \frac{1}{3} : 2 \frac{2}{5} = 2 \frac{1}{3} \times 2 \frac{2}{5} = \frac{7}{3} \times \frac{9}{2} = \frac{63}{6} = \frac{21}{2} = 10 \frac{1}{2}
\]

An analysis of these data leads one to believe that the student:

a) does not understand the nature of a "mixed number."

b) cannot multiply rational numbers.

c) does not understand the commutative property of addition of rational numbers.

d) failed to change the numerals to improper fractions as an initial step in the algorithm.

5. A sixth grade student computed the average value and the range of the set of numbers 24, 35, 46, 27, 43, 38, 26, and 33 in the following manner:

\[
\begin{align*}
24 & \\
35 & \\
46 & \\
27 & = 272 \\
43 & \\
38 & \\
26 & \\
33 & \\
\hline
272 & \text{Average: 34} \\
\end{align*}
\]

\[
\begin{align*}
34 & \\
46 - 34 = 12 \\
12 \times 2 = 24
\end{align*}
\]

An analysis of these data leads one to believe that the student:

a) does not know how to compute the "average" of a set of natural numbers.

b) does not understand the meaning of the term "range."

c) does not know the rule defining the "order of operations."

d) assumed the numerical value of the average to be midway between the maximum and minimum values in the set.
6. A fifth grade student renamed 652 - 384 in the following way:

\[
\begin{array}{c}
652 \\
-384 \\
\hline
332
\end{array}
\]

An analysis of these data leads one to believe that the student:

a) does not understand expanded notation.
b) does not know the basic subtraction facts.
c) erroneously thinks that subtraction is commutative.
d) cannot apply the subtraction algorithm for whole numbers.

7. A sixth grade student renamed \(2 \frac{3}{5} + 1 \frac{2}{3}\) in the following way:

\[
2 \frac{3}{5} + 1 \frac{2}{3} = 2 \frac{9}{15} + 1 \frac{10}{15} = 3 \frac{19}{30}
\]

An analysis of these data leads one to believe that the student:

a) does not know how to add proper fractions.
b) does not understand the concept of greatest common factor.
c) does not know how to add "mixed numbers,"
d) does not understand the concept of equivalent fractions.

8. A fourth grade student renamed \(5 \div 0\) in the following manner:

\[
\begin{array}{c}
5 \\
\hline
0
\end{array}
\]

An analysis of these data leads one to believe that the student:

a) does not know the basic division facts.
b) does not understand the definition of division.
c) has stated a true number sentence.
d) does not know that the number zero is the identity element for addition in the set of whole numbers.
9. A second grade student renamed $48 + 37$ in the following way:

\[
\begin{array}{c}
48 \\
+ 37 \\
\hline
715
\end{array}
\]

An analysis of these data leads one to believe that the student:

a) does not understand the rule defining the "order of operations."
b) does not understand the concept of regrouping.
c) does not know the basic addition facts.
d) does not understand the concept of "place value."

10. A fourth grade student renamed $23 \times 47$ in the following manner:

\[
\begin{array}{c}
23 \\
\times 47 \\
\hline
16 \quad 3 \\
\hline
2 \quad 3 \quad 3
\end{array}
\]

An analysis of these data leads one to believe that the student:

a) does not know the basic multiplication facts.
b) does not understand the distributive property of whole numbers.
c) does not understand the "decimal (base ten) aspect" of our system of numeration.
d) does not understand the concept of "place value."

11. A fifth grade student renamed $\frac{4}{5} + \frac{2}{3}$ in the following manner:

\[
\frac{4}{5} + \frac{2}{3} = \frac{4 \times 3}{15} + \frac{2 \times 5}{15} = \frac{6}{15} = \frac{2}{5}
\]

An analysis of these data leads one to believe that the student:

a) does not understand the concept of equivalent fractions.
b) cannot add rational numbers.
c) does not understand the concept of "place value."
d) does not understand the concept of least common multiple.
12. A sixth grade student renamed $2\frac{7}{8} - 1\frac{2}{3}$ in the following way:

$$2\frac{7}{8} - 1\frac{2}{3} = 2 \frac{21}{24} - 1 \frac{16}{24} = \frac{23}{24} - \frac{17}{24} = \frac{6}{24} = \frac{1}{4}$$

An analysis of these data leads one to believe that the student:

a) cannot subtract common fractions.
b) does not understand the concept of proper fraction.
c) cannot convert a "mixed number" to an improper fraction.
d) does not understand the concept of "mixed number."

13. A third grade student renamed $4(3 + 2)$ in the following way:

$$4(3 + 2) = 12 + 2 = 14$$

An analysis of these data leads one to believe that the student:

a) applied the commutative property incorrectly.
b) misapplied the distributive principle.
c) should have determined the sum of three and two as an initial step.
d) does not know the basic addition facts.

14. A sixth grade student renamed $\frac{7}{8} : \frac{3}{4}$ in the following manner:

$$\frac{7}{8} : \frac{3}{4} = \frac{8}{7} \times \frac{3}{4} = \frac{2}{7} \times \frac{3}{1} = \frac{6}{7}$$

An analysis of these data leads one to believe that the student:

a) does not understand the concept of least common multiple.
b) cannot multiply proper fractions.
c) incorrectly "inverted" the dividend.
d) does not understand the meaning of division of rational numbers.
15. A fifth grade student renamed $\frac{b}{3}(10)$ in the following manner:

$$\frac{b}{3} \times 10 = (4 \times \frac{1}{3}) \times 10 = 4 \times (\frac{1}{3} \times 10) = 4 \times \frac{20}{10} = \frac{20}{10} = 2$$

An analysis of these data leads one to believe that the student:

a) does not understand why he converted $\frac{b}{3}$ to $4 \times \left(\frac{1}{3}\right)$ in the first step of his argument.
b) does not understand the concept of least common multiple.
c) does not understand the associative property of multiplication of rational numbers.
d) does not understand how to multiply a natural number and a proper fraction.

16. A fifth grade student employed the open sentence $3x + 1 = f(M)$ to compute the values (shown in red) in the following table:

<table>
<thead>
<tr>
<th>M</th>
<th>3</th>
<th>0</th>
<th>8</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>f(M)</td>
<td>12</td>
<td>3</td>
<td>27</td>
<td>21</td>
<td>18</td>
<td>15</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

An analysis of these data leads one to believe that the student:

a) did not multiply before he added.
b) does not understand the distributive property of whole numbers.
c) does not understand the concept of multiplication.
d) does not understand the rule defining the "order of operations."
17. A fourth grade student renamed $63 \div 4$ in the following manner:

\[
\begin{array}{c|c}
4 & 63 \\
\hline
40 & 10 \\
23 & 5 \\
20 & 3 \\
\hline
3 & 18
\end{array}
\]

$63 \div 4 = 18$

An analysis of these data leads one to believe that the student:

a) does not understand the concept of division.
b) does not know how to subtract whole numbers.
c) does not understand the nature of a remainder.
d) does not understand the concept of regrouping.

18. A third grade student renamed $705 - 228$ in the following way:

\[
\begin{array}{c}
705 \\
-228 \\
\hline
377
\end{array}
\]

An analysis of these data leads one to believe that the student:

a) does not understand regrouping.
b) probably "borrowed" from "seven" twice.
c) does not know the basic subtraction facts.
d) does not know that the number zero is the identity element for addition in the set of whole numbers.
19. A sixth grade student renamed $3 \times (\frac{5}{6})$ in the following manner:

$$3 \times \left( \frac{5}{6} \right) = 3 \times \left( 5 \times \frac{1}{6} \right) = (3 + 5) \times \frac{1}{6} = 8 \times \frac{1}{6} = \frac{8}{6} = \frac{4}{3}$$

An analysis of these data leads one to believe that the student:

a) incorrectly changed a multiplication symbol to an addition symbol.

b) does not understand the concept of "mixed number."

c) does not know how to find the product of a natural number and a unit fraction.

d) does not understand the associative property of multiplication of rational numbers.

20. A first grade student "counted" the objects in the set below in the indicated manner:

An analysis of these data leads one to believe that the student:

a) does not know the correct serial order of the number names.

b) does not understand the difference between "number" and "numeral."

c) does not understand the role of the one-to-one correspondence in counting.

d) failed to name the fifth element in the set.
Read the statements below. Choose statements which show your feelings toward arithmetic. Let your experiences with this subject in the elementary school determine the marking of items.

Place a check (✓) before those statements which tell how you feel about arithmetic. Select only the items which express your true feelings—probably not more than five.

1. I avoid arithmetic because I am not very good with figures.
2. Arithmetic is very interesting.
3. I am afraid of doing word problems.
4. I have always been afraid of arithmetic.
5. Working with numbers is fun.
6. I would rather do anything else than do arithmetic.
7. I like arithmetic because it is practical.
8. I have never liked arithmetic.
9. I don't feel sure of myself in arithmetic.
10. Sometimes I enjoy the challenge presented by an arithmetic problem.
11. I am completely indifferent to arithmetic.
12. I think about arithmetic problems outside of school and like to work them out.
13. Arithmetic thrills me and I like it better than any other subject.
14. I like arithmetic but I like other subjects just as well.
15. I never get tired of working with numbers.
16. Place a circle around one number to show how you feel about arithmetic in general.

1 2 3 4 5 6 7 8 9 10 11
Dislike             Like
Directions: Please respond to each of the following items. Follow the directions given in each of the statements. DO NOT circle more than one number in a given item.

1. Place a circle around one number to show how you feel about the prospect of teaching elementary school arithmetic.

   1 2 3 4 5 6 7 8 9 10 11

   Apprehensive                 Confident

2. Place a circle around one number to show how you feel about the likelihood that elementary school children will be able to learn "modern mathematics."

   1 2 3 4 5 6 7 8 9 10 11

   Unlikely              Likely

3. Place a circle around one number to show how you feel about the importance of including live observations of student-learning activities as a component part of a teaching-methods course.

   1 2 3 4 5 6 7 8 9 10 11

   Nonessential               Essential

4. Place a circle around one number to show how you feel about the use of the NCTM films to replace live classroom observations.

   1 2 3 4 5 6 7 8 9 10 11

   Disapprove                  Approve
APPENDIX D

Observation Outline
Each observer should be prepared to discuss each of the following points at the class-meeting following the observation.

I. LESSON OBJECTIVES
   A. Explicitly stated?
   B. Implied?
   C. Not discernible?

II. TEACHING METHOD
   A. Discovery? Type?
   B. Demonstration?
   C. Exposition?

III. TEACHING AIDS
   A. Equipment used?
   B. Appropriateness?

IV. TEACHER-STUDENT VERBAL BEHAVIOR
   A. Teacher (Indirect Verbal Behavior)
      1. Accepting student feeling.
      2. Giving praise.
      3. Accepting, clarifying, using student ideas.
      4. Asking a question.
   B. Teacher (Direct Verbal Behavior)
      1. Lecturing, giving facts or opinions.
      2. Giving directions.
      3. Criticizing or justifying authority.
   C. Student Verbal Behavior
      1. Response to teacher or fellow student.
      2. Student initiated talk.

V. NONVERBAL BEHAVIOR
   A. Teacher?
   B. Student?

VI. DESCRIBE THE FOLLOWING:
   A. Positive things you observed.
   B. Negative things you observed.
   C. Things you would have done differently had you been the teacher.