THE UNIVERSITY OF MANITOBA

A THREE FACTOR ANALYSIS OF VARIANCE OF THE ACHIEVEMENT DIFFERENTIALS PRODUCED BY INTERACTIVE INTRACLASS GROUPING

BY

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ABSTRACT

The major purpose of this study was to investigate the effect of small interactive intraclass grouping upon individual achievement in elementary science. This effect was studied (1) with respect to high and low mental ability; (2) with respect to high, middle, and low socio-economic status; and (3) <u>without</u> regard to either of mental ability or socio-economic status. In addition (4), the effect of socio-economic status, only, upon elementary science was also investigated. The comparisons were made at the grade six level using three science lessons.

The experimental design involved a three-factor analysis of variance using a mental age factor of two levels, a socio-economic status factor of three levels, and the treatment factor with experimental and control levels.

The lessons were uniformly administered and the same instructor was used throughout. Post tests were given to determine achievement differences. These instructor-made tests were combined into a single science achievement measure. This composite measure had a reliability coefficient of .70 as computed using the Kuder-Richardson and Hoyt method.

The sample consisted of 345 grade six pupils using two classrooms from each of seven schools distributed throughout urban and suburban areas. The samples were nearly identical with respect to mental age distribution and to socio-

economic status of parent.

Without regard to mental ability or socio-economic status, the experimental intraclass grouping produced significantly greater science achievement at the grade six level than was produced by the independent work methods of the control individuals. A statistically significant difference in achievement in favour of the experimental groups was found for the higher mental ability and the higher socio-economic status students, diminishing to almost identical achievement for the experimental and control subjects at the lower mental ability and the lower socio-economic status levels. Pupils in the experimental groups achieved significantly greater on the lesson judged to be the most difficult.

Pupils in the higher levels of socio-economic status achieved significantly greater on the science tasks than did those in the lowest socio-economic status level.

Results provided by an attitude inventory showed considerable student preference for working in a social context rather than in individualized private study.

The findings of the study support the use of intraclass grouping as an administrative device capable of providing considerable economic benefits in terms of materials while, at the same time, providing for equal or greater teacher efficiency.

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THE PROBLEM, DEFINITION OF TERMS, AND IMPORTANCE

For purposes of instruction, to group, or not to group, is still a question. Evidence supporting or refuting the one method or the other has only managed to cloud and confuse the issue. Proponents of grouping make claims that are beyond the ability of groups to deliver. Opponents of grouping emphasize negative consequences. Many teachers would welcome concise information related to the level, the subject matter, and the settings for which grouped or individualized instruction is likely to be effective.

I. THE PROBLEM

Statement of the Problem

It was the purpose of this study to investigate the effect of small "interactive intraclass" grouping upon the achievement of individuals in science at the grade six level. This effect upon achievement was compared to that of individuals in similar grade six classes taught without such grouping. The effect was investigated (1) independently of mental ability and socio-economic status; (2) in relation to high and low mental ability; (3) in relation to high, middle, and low socio-economic status. In addition (4), the effect of socio-economic status upon grade six science was also investigated. Further (5), information was sought regarding student preferences for working individually or in groups.

Definition of Terms

Certain terms were used frequently throughout the study and should be clarified at this point.

Small interactive intraclass group. For the purpose of this study a "small" group was composed of from four to six individuals. Smaller numbers would normally be referred to as pairs or triads and were considered as inappropriate for this study in terms of economy of materials. Larger numbers would have been inappropriate for personal interaction with the materials shared by the group and, hence, were not used. The groups of individuals in this study were encouraged to interact verbally with each other in relation to the equipment and the problems assigned. Such interaction was to provide intellectual and motivational stimulation together with opportunities to share and transfer skills and achievement information.

"Intraclass" group was described as a group set up within an existing class or section. With so many current usages of the term "group" it was necessary to use the adjective 'intraclass' to distinguish the experimental group of this study from other connotations such as 'the class group,' a 'control group,' or a 'homogeneous group.'

Achievement. For the purpose of this study, individual achievement was the score obtained by each individual on each science post test as given after each instructional period.

Socio-economic status. The socio-economic status of the father normally defined the socio-economic status of each pupil. In the case of a deceased father, or foster parents, the socio-economic status of the present wage-earner was considered to be appropriate.

Discovery lesson. A discovery lesson was the type of lesson that required the subjects to make their own decisions whenever achievement content was involved. These decisions, or answers to the posed problems were to be "discovered" by working with the science materials given out for this purpose. The instructor supplied only open-ended statements of purpose along with directions dictated by the the nature of the apparatus.

ANOVA. The term "ANOVA" has become a fairly common abbreviation for "Analysis Of Variance." Since this was the method of statistical analysis used for this investigation the term ANOVA is used when appropriate to do so.

II. IMPORTANCE

Importance of the Study

"Developing in children inquiring and independent minds, powers of critical thinking and self reliance" was rated number one of crucial problems in educational administration by Canadian superintendents in 1966 (Kitchen, 1962). Bany and Johnson (1967, p. 27), the proponents of group oriented classrooms, believed that individuality and originality in individuals were developed through group participation. They placed great emphasis upon individuals working together, and stated that the group provides support for individual learning. Positive group forces were to be used to develop individuals who were self-directing, who would have inquiring minds, and who would form their own judgments as to truth (pp. 22-26). Bany and Johnson (pp. 363-365), also maintained that planned approaches to the study of groups could be profitably done and that there was a need for normative standards to be established.

According to Lifton (1967, p. 220), there was a surprising lack of research on how one most wisely devised adequate learning episodes for children at different ages and in different subject matters. He suggested that there was little doubt that many group-process questions needed investigation.

Hartup (1967, p. 214), maintained that, in relation to peers as agents of social reinforcement, there was very litle experimental literature concerning the capacity of peers to influence the learning and performance of children. Recent literature suggested that reinforcement emanating from peers has extremely complex effects upon children's task performance. The kinds of interactions a child has with other children in the nursery school appear to have far-reaching effects on his responsiveness to social influence. It was suggested that many dimensions of peer group functioning need to be examined and manipulated in experiments using peers as agents of reinforcement (p. 227).

Bany and Johnson (1967, pp. v-3) further added to the argument for research in the classroom. They considered that the classroom group setting and the class group interactions have an important influence upon individual learning and behavior. Their argument included the thesis that the study of the class as a group and its influence upon individual behavior would give significant insights into productivity and effectiveness in the learning process. They stated that there has been too much concentration upon the individual and how he relates to the group and not enough attention to the group and its influence upon the individual. Also suggested is the argument that development of good feeling must precede as well as accompany the usual school curriculum, for without it, little or nothing can be accomplished.

Eiss and Harbeck (1970, pp. 4-7) emphasized the importance of the affective domain as a screening or monitoring device that effectively blocks cognitive or psychomotor learning if the feeling for the stimulus or its 'value' is low or nonexistent.

Lippitt (1961, pp. 25-27) argued for strong and cohesive action groups in our society today. He cited examples from a growing body of evidence to show that individuals are terribly in need of the "freedom from a neurotic anxiety of isolation from fellow men." At all levels individuals need and depend upon the acceptance of, and the inclusion in, meaningful and strong groups. He suggested the need to answer such questions as: Do classroom groups have a strong effect upon the individual's motivation and ability to learn? Do groups have strong influences upon the pupil's performance as a learner? What are some of these classroom conditions promoting a healthy pattern of relationships between the individual and the group?

Heathers (1969, pp. 567-8) summarized research on the "small intraclass group" in the Encyclopaedia of Educational Research. While he drew attention to the mere handful of intraclass studies of the evaluative type, he suggested that the 1970's would see a great deal of research in intraclass differentiation of instruction, but with much of it being in support of the individualization of instruction.

Hunter (1970, pp. 53-64) saw small groups as the logical means of administratively handling individualized programs. Such programs tailored to match the needs of the individual do not conflict with instruction using small groups of students. While she tended to see groups used primarily for the efficient administration of teacher purpose and planning, certain types of higher cognitive level involvement were considered as requiring interactive participation some of the time.

Interactive intraclass grouping may have something to contribute to improvement of instruction, individualized, or otherwise. If it also contributes to enjoyment of school, increased motivation, better mental health, while yielding the same level of achievement as other instructional modes, then it deserves consideration as a viable teaching technique.

Although obtaining information about achievement differentials contributed by small interactive intraclass grouping was the main purpose of this study, it must be emphasized that long and short-range side effects of the social interactions of groups are also involved with achievement. Considerations of possible positive or negative side effects may affect the reasons for intraclass grouping, since, on a day-to-day basis, achievement differentials may be almost negligible in many situations. It was for these reasons that the affective domain literature dealing with these other factors was included in the survey of the literature.

Intraclass grouping and small group instruction is a necessary skill requirement of many teachers. Even open-area classrooms, with their emphasis upon individualization, require small group practices that were less common only a short while ago. In some of these open areas for reasons of cognitive stimulation and pupil interaction group instruction is being supplanted by the use of programmed or 'contractual' materials--all of which isolate individuals unless certain deliberate or systematic techniques are used to provide meaningful interaction with peers.

Out of school, small groups of people are a fact of life. It is important that young people are educated to utilize them effectively. If there are positive effects to be gained from membership in such groups, then pupils in the schools should be given opportunities to share these rewards. If there are negative effects resulting from membership in small groups, then students need guided experiences to help them learn how to minimize such negative consequences.

A survey of the literature uncovered voluminous arguments in favour of working, participating, learning, and otherwise utilizing group experiences--in spite of acknowledged problems and deficiencies. This enthusiasm about the many possible contributions small groups could make to the classroom learning or achievement situation has prompted the undertaking of this investigation.

Limitations of the Study

While this study attempted to include or control many major variables, it should be noted that there are many unknown dimensions to human behavior. Because of these, care should be taken when generalizing the results of the study to other grade levels, other types of science lesson or lesson administration, or to groups constituted by other means.

The sample. The sample had some limitations. It was not rigorously matched and paired. Rather, reliance was placed upon the randomization effects produced by a sufficiently large sample, which, in this case, was selected for the purpose of producing approximately thirty subjects in each of the twelve cells used in the analysis. Thirty is usually the minimum number required to produce frequency distributions of means which closely represent the distribution of a parent population (Garrett, 1956, p. 92).

During the study the initial sample of 462 subjects was depleted to 378 by student illness or absence, or due to the lack of some portion of information for certain students. Balancing the numbers of each factor and each cell made it necessary to remove another thirty-three. The final average for each cell was just below twenty-nine, slightly under the the recommended minimum of thirty. However, other authors considered that cell numbers of fifteen to twenty subjects were suitable for most ANOVA designs (Bruning and Kintz, 1968, p. 3).

The time variable. Control of the time variable was difficult. Being required to operate within the framework of a regular school timetable imposed severe restrictions.

The use of a reasonably large sample automatically brought with it the necessity of operating within the limits of the lowest common denominator with respect to school period lengths.

The total time of pupil interaction with the problems, materials, and subject matter, was sixty minutes, exclusive of administration time, testing, and cleanup. Achievement related to this was further compressed into three ten-minute tests. Incremental differences produced by either the experimental or the control groups would, of necessity, be very small. A longer investigation time, with a much larger amount of subject matter, would allow possible differences to either become larger or to be minimized--should they be the result of some unusual variant in only one or two lessons.

The administration variable. Uniformity of administration, while apparently controlled--the same instructor administered all classes--may have been subject to such variables as, for example, the differing perceptions to freedom as exercised in small groups as compared to perceptions about restrictions by those who worked individually.

Mental ability variable. The measurement of mental ability was not done by the investigator. The results of previously administered group tests of I.Q. were accepted as being reliable enough for the purposes of a dichotomous classification. Variations due to previous administrations of these tests were assumed to be randomly distributed throughout all cells, with both experimental and control samples each receiving their share of each type of test administration. Students with records of reading disability were removed from the sample since they would not likely have valid mental ability measures.

<u>Reliability of science measure</u>. The lack of suitable standardized and reliable tests of achievement specific to the three topics chosen made it necessary to use three science measures designed by the investigator. Another limitation of the tests, in terms of achievement, was their inability to measure new achievements in terms of skills, methods of problem-solving, or other broad spectrum areas that may result when one works with others, or conversely, has the opportunity to handle apparatus and to do things without interference from others.

CHAPTER II

A SURVEY OF THE LITERATURE

This survey of the literature has brought together some of the arguments that showed, directly and indirectly, the influence that the small interactive group has had upon achievement and learning by individuals in such groups. The more generalized and conceptualized of these writings have been included under the heading of descriptive literature. The more statistical quantitative references have been summarized under the heading of evaluative literature.

I. DESCRIPTIVE LITERATURE

The descriptive literature has been subdivided into sections that present arguments showing the relationship of the small group to motivation, social-emotional needs, security, behavior change learning, feedback and operant conditioning, and the quality of learning. The inter-related nature of the topics has made the classification into such clear-cut topics quite arbitrary but the separation was intended to follow the main emphases.

The Small Group and Motivation

If motivation is simply defined as some kind of driving force in an individual--a kind of initiating and sustaining force of behavior moving or inducing an individual to achieve or learn, then any small group contribution to motivation becomes an important contribution to learning or achievement.

According to Bradford (1961, p. 34), the motivating dynamics of small groups in the educational process have just begun to be adequately explored. He maintained that group forces are potentially highly supportive of individual learning, but that these forces have neither been released generally, nor when they have operated, have they acted to support the teacher's objectives. Indeed, the author noted that the forces may even cause barriers to future learning situations with lasting anxieties and undesirable attitudes toward education.

Hartup (1967, pp. 104-111) cited studies by Frances Horowitz that gave strong evidence of the motivating effect of social reinforcers upon performance tasks. There were slight differences at the kindergarten level, greater differences at the fourth grade; with greater differences being observed for verbal reinforcement tasks than for buzzer reinforcements. The author stated: "It becomes apparent from this summary of evidence that the learning process is directly influenced by social reinforcement."

On the basis of another study, Horowitz concluded that decision-making in groups caused motivational energy to be channeled into action and indicated that motivation was involved with group planning and with sharing in the decision making (Bany and Johnson, 1967, pp. 177-8).

In the Handbook of Small Group Research, the following points were noted with respect to the social influence of small groups and its motivational effect upon the individual. Motivation that is dependent upon social influencers is very persistent and may be more effective than might be suspected, since prevention of social goals causes more frustration than food deprivation. Expectations of other group members influence motivational forces (Hare, 1965, pp. 92-101).

The effect of groups in motivation and to social interplays was documented in the famous Hawthorne studies. Olmsted (1959, pp. 14-34) reported on the Western Electric relay assembly room which showed that social forces served to enhance the favorable reaction of individual operators to the experimental situation, creating new drives to increased output. Also cited was the "Bank-Wiring Room" extension of the same study, again showing the strong social forces capable of limiting or increasing production.

DiVesta's studies (1961, pp. 511-534) confirmed the motivational influence of group settings. One important and relevant side-benefit was noted: anxious individuals, while attempting to solve difficult problems, had greater achievement in co-operative groups.

Hollander (1967, pp. 104-111) cited studies that support the concept of motivation produced by reinforcement due to groups. The group reinforces an individual's sense of accuracy, produces a more persisting response, and a greater response strength as measured by resistance to extinction. An operant conditioning type of reaction is also produced. Social influence is looked upon as a new experience involving learning. The exposure to change and novel experience or information is a central feature of social influence with its ability to provide new learning experiences along with social support--a support, not pressure, that provides a favourable influence for an individual in behavioral situations. Pleasurable associations are developed that increase the probability of a repeated response.

The view that groups bring higher intelligence members down to the level of some common denominator has found little support from subsequent studies (Hollander, 1967, p. 35).

The social nature of learning, including the motivational effects, was supported by a study reported by Brookover and Erickson (1969, pp. 1-17). The learning of a language, considered by some people as being a difficult task, illustrated their point for "...even idiots learn French in France."

Caldwell (1960, pp. 3-4) maintained that learning is not an impersonal process. To him, children would rather learn from people, especially their peers. Resistance to learning may only be reluctance to learning from books.

The Small Group and Security to Learn

The relationship to social support, rather than to social pressure, is a rather new concept with regard to groups and motivation for learning. In this respect, security--which can be defined as the feeling that one has when physical and social-emotional needs have been met--may be an important ingredient of the achievement-learning process, and may be one of the more important group contributions.

Bany and Johnson (1967, pp. 39-42) supported the use of classroom grouping with evidence that groups fulfill a child's developing needs, making the child a more satisfied contributing learner. If most of his needs are not satisfied to some extent by his group and its activities, very little learning occurs.

Gibb (1961, p. 52) supported this relationship of security to learning when he agreed that it is important to meet the social-emotional needs of students. He cited evidence that a supportive climate maximizes the learning in the classroom. Students feel less need to defend themselves, their ideas, and their suggestions.

Biggs (1965, pp. 77-92), writing in the International Review of Education, described learning as that which is exhibited by changed behavior rather than by memorized rules, facts, simple rote, or recall. Bradford (1960, pp. 443-450) agreed with this concept and suggested that most behavior changing takes place in a secure, anxiety-free environment.

If the concept of learning as a behavior change is accepted, and if behavior change does require a secure and anxiety-free environment, then the supportive function of the small group may operate with more subtle effects than has usually been considered.

The recent notion that a group is necessary to provide emotional support and security for an individual to change his thinking on his own volition is definitely opposed to conclusions that usually arise regarding the conformity experiments such as those conducted by Asch (Krech, et al, 1962, pp. 507-8).

The social scientists associated with the National Training Laboratories at Bethel, Maine, have supported the security concept as necessary for behavior change learning. Bradford (1962, pp. 14-32) considered learning to be a behavior change requiring the secure environment of a 'primary' group. Change was viewed as painful and difficult, with the need of sympathy and emotional support, best given by a group, to reinforce the individual in his efforts to change. Because change requires moving from a position of relative security or familiarity to a less familiar position, the process of changing is often perceived by the individual as opening up a variety of threatening experiences. The Bethel scientists did not negate Asch's findings, and conceded that the group may also produce negative results, depending upon its structure.

Bany and Johnson (1967) also reinforced the concept that a group is a security provider for behavior change learning: "Sometimes the most important help a child can receive is from some of his classmates who accept and provide him with emotional support when the learning task is painful" (p. 93).

Lifton (1961, pp. 14-28) reported a study by Wieder which indicated that attitudes were measurably modified by group techniques whereas those taught according to traditional methods did not significantly modify the same attitudes. Lifton saw conditions for good learning situations as having to be similar for both education and therapy, with secure settings being a requirement for learning.

Behavior change learning may be greatly facilitated by allowing group members to participate in decision-making. Change through groups is more permanent than changing singly. The now famous "war-time meats study" showed that lecture groups only changed three per cent of the buying behavior of customers whereas thirty-two per cent of the discussion groups changed behavior. The Kurt Lewin dictum that it is easier to change the group than the individual was confirmed. Lewin also maintained that changing an individual makes only a deviant, that it is the groups that must be changed (Bany and Johnson, 1967, pp. 285-91).

These same authors considered the acquirement of a type of knowledge that leads to a change in behavior as perhaps one of the highest priority problems facing educators today. Group involvement has much to contribute to behavior change learning. Group techniques create a shared perception of a need for change and thus increase teacher effectiveness and group productivity (pp. 291-341).

Hare (1962, pp. 47-93) reported evidence in terms of the need for a group to provide a change atmosphere. The group may also provide a means to break down an old value system that is based upon faulty reasoning or judgment and thus may pave the way for new learning.

The Small Group as a Feed-Back Device

Immediate knowledge of results is an important component of most learning. Such feed-back is the necessary part of successful operant conditioning. Whether it was involved directly or indirectly with learning, achievement or motivation, many writers argued that immediate feed-back was provided by groups, and gave it credit for improving the quantity and the quality of learning.

Bany and Johnson (1967, pp. 99-102) cited a Pryer and Bass study which showed that feed-back had an important effect upon the quality of learning. The study involved groups of children. The authors noted that teacher-leader roles that were participatory rather then supervisory were also necessary to improve the quality of feed-back.

Hare, Borgatta, and Bales (1965, pp. 434-494) reported a study that showed feed-back as giving significantly higher scores while zero feed-back accompanied low confidence and hostility.

Bradford, Gibb, and Benne (1964, p. 201) noted that there were many reasons why peer influence was effective for learning. The peer is perceived to be in the "same boat," defensiveness resulting from fear of exposure is reduced. A group of peers was seen as having more sources of data and more 'refractory mirrors' for feed-back. Peers are not likely to raise the authority problems that frequently distort or inhibit learning in a superior-subordinate relationship. Peer feed-back sources tend to be more stable and reliable.

Duckworth, the author of "Piaget Rediscovered" (Victor and Lerner, 1967, p. 320), stated: "When I say 'active' I mean it in two senses. One is acting on material things. But the other means doing things in social collaboration; in a group effort." Apparently Piaget thought social interaction was important. Piaget viewed it as leading to a critical frame of mind where children must communicate with each other--an essential factor in intellectual development. Duckworth stressed Piaget's emphasis upon the provision of a social medium for a child to conceive points of view other than the child's own. Coming to an awareness that another child sees something differently from the way he sees it plays an important role in helping a child to accomodate, to rebuild his point of view, and to come closer to a coherent operational structure.

The Small Group and Quality of Learning

Man cannot think clearly alone. He requires the

> checks and balances of other men and normally seeks conference and counsel when it is his purpose to act in accord with a wider wisdom. Modern life presents problems too complex for the individual to solve and demands specialized skills and knowledge too varied to carry around in 'one small head.' One individual cannot have had all the experiences that are required in a situation in which decision affects many people. (Lane and Beauchamp, 1955, pp. 43-44).

As well as providing immediate knowledge of results, the small group also supplies promptly the group's resources in a problem-solving situation. This section of the related literature gives the arguments of the writers who agreed with Lane and Beauchamp, but also includes those authors who further suggested that a productive group was able to build a chain of association in such a manner as to produce a more stimulating environment for all. These writers saw this enriched verbal atmosphere as being able to provide a more precise use of words and hence to develop better cognitions. This additional feed-back contribution also was seen as being able to affect motivation.

According to Olmsted (1959, pp. 86-88) group interaction also affected the quality of learning. He reported that groups were more effective at doing problematic and reasoning varieties of tasks, and that the group was especially effective at checking errors of logic. Olmsted also reported that there was still no conclusive research favoring individuals over groups in brainstorming activities; although one study was reported as showing the total for individuals equalled the total for a group in a non-problem-solving variety of task.

Hollander (1967, pp. 364-85) noted that for simple tasks individuals may do very adequately, but for a complex task the resources afforded by several people working together are likely to be more suitable. Groups are the means to provide a forum upon which cognitive development may take place rather than being a means to impose conformity.

Lane and Beauchamp (1955, pp. 46-7) considered that group intelligence builds finer responses and a finer quality of human being. Group planning considers <u>all</u> alternatives in terms of hypothetical consequences.

The need for opportunities to allow children to practice critical thinking by using discussion to examine and exchange ideas was voiced by Trump (1961, p. 6), while Alberty (1962, p. 104) argued that this kind of reflective-thinking learning was more significant than the conditioned response type in terms of the needs of a democratic society. Alberty also agreed that security and motivation were likely to augment reflective thinking while he also noted that requirements of speed and pressure act to diminish it.

The contributions that small-group, co-operative learning can make to the development of independence, maturity, powers of critical thinking, self-reliance, and personality growth are important. Moore (1967, p. 244), studying peer acceptance in nursery school children, found that groups allow a child to transfer dependence from parents and teachers to peers in the group. This transfer of dependence is an important step in development to maturity.

Bany and Johnson (1967, pp. 343-351) considered problem defining to be a very important part of the process of learning, and that it was preferably done by groups. Formulating an idea for communication leads to a sharpening or refining of that idea. Subject matter presented in the form of topics, questions, projects to be planned, producing reports, studying problems that beset society, solving of group difficulties, assures problem-defining practice. The skills and processes involved in such practices are themselves very important.

Taba, cited in Lee (1966, p. 106), supported group interaction as an aid to the conceptualization and the cognitive handling of information. To her, learning was interacting with ideas <u>and</u> with people.

Free interaction groups were shown by Wolfgang (1967, pp. 36-40) to have better concept identification than did restricted interaction groups. This identification was even more marked in superiority if irrelevant information was included in the concept search.

Roeper and Sigel (1967, pp. 85-86) also agreed with the necessity for group discussion:

> Discussion, in which generalizing and verbalizing in relation to newly found understandings helps protect the child against being overwhelmed by superficial and erroneous visual evidence. This type of discussion itself helps the child towards

acquiring the ability to conserve (p. 85).

The Roeper and Sigel studies demonstrated that verbalizing and clarifying three Piagetian processes by group interaction not only helped understanding of the processes, but also enabled the children to apply the processes independently. "It was impressive to observe the moment of recognition in one child, who was then able to convince the next" (p. 86).

The Small Group and Stimulating Environment

This section includes discussion about the motivational, feed-back, and cognitive contributions of the small interactive group--particularly in terms of combinations of these three contributions that produce what might be called a more stimulating nevironment. Such a rich environment was seen by some authors as being very important during the early cognitive development of children while others saw the security and the stimulation as being necessary for the development of personality and good mental health.

The importance of a stimulating environment was stressed by Hunt (1961, p. 363) and by Sava (1968, pp. 103-104). They saw a stimulating environment as a necessary requirement for structuring a system of neural and synaptic connections in the brains of the very young. This structured system then provided for a greatly increased ability to learn.

In addition to this stimulating environment concept, Hunt and Sava both agreed that experiences should be matched to the learner. If the "proper discrepancy" or challenge of subject matter is adjusted so that the material is not so easy as to be avoided as boring, nor so difficult as to cause avoidance due to frustration, then the child will learn and continue to learn at a much greater rate.

In terms of verbal symbolism, one might argue that a vigorous interactive group of peers should add considerable verbal stimulation to any existing physical environment. Part of the contribution would be an immediate feed-back system while the other part would be a source of ideas; both of which are more likely to match the learning levels of youngsters than is a busy adult engaged elsewhere with other students or with other teaching duties.

Evans (1968, pp. 458-68) suggested it was necessary to have a curriculum of maximum breadth to supply intellectual stimulation and saw groups with diverse potentialities as assisting to supply this wider range.

Olmsted (1959, p. 48) visualized groups as a type of "nutrient medium" in which the development of the individual takes place, and further suggested that while schools may be undertaking the task of teaching the child to think, they cannot neglect the task of developing his personality.

The Small Group and Personality

The enhancement of self-autonomy and personality is likely to contribute other effects. Whyte (1956, p. 64) stated that the Institute for Social Research at the University of Michigan has much evidence of the benefits from increased attention paid to morale and self autonomy. These benefits include more skill and more effort.

Williamson (1939, p. 177), writing from the standpoint of mental hygiene, maintained that one of the greatest needs in education was for teachers who could create situations in which normal personalities may develop. Sprott (1958, p. 186) saw personality enrichment as another side-benefit of groups. To him, the individual was primarily a social product, needing interaction for the development of his personality. The wider the range of interaction, the richer the personality will become. The presence of others greatly influences behavior. Individuals enjoy co-operation more than competition, and are prepared to put forward more effort as team members than they would on their own.

Lane and Beauchamp (1955, pp. 57-118) agreed with the notion that interaction has a wide range of effects. They concluded that every day, every child should participate in group enterprises that employ energies, thought, skills, and talents in the improvement of the quality of living in the group. This should include opportunities every day to exercise group planning and group action.

Summary of Descriptive Literature

The relationship between motivation and learning is well known. The effect of the small group with its social reinforcement has been shown to contribute to both physical and verbal learning. Motivation is also related to group decision-making, where its persistence has been noted. The development of a language supports one definite aspect of the social nature of learning.

There is a relationship between security and learning. If security is obtained when both social and physical needs are met, then groups, with a demonstrated ability to supply both social and emotional needs, contribute to security and hence contribute indirectly to learning requirements. Apparently security is a necessary ingredient of "behavior change" learning--as contrasted with simple rote or recall level of cognitive development. In this sense, groups do not make individuals conform, but rather provide a climate of emotional support while an individual goes through the anxious state of changing his mind.

Immediate knowledge of results or 'feed-back' is also provided by interactive groups. This operant reward system improves the verbal symbolism and the cognitive quality of achievement and learning. Besides providing a motivational impetus, this immediate feed-back and the breadth of opinions brought to bear on topics or problems makes it possible for groups to complete judgmental tasks faster and more accurately than individuals are likely to do.

Groups contribute to the development of personality, growth to maturity, and, by bringing together wider ranges of experiences, provide more challenge, greater motivational impetus, and higher quality cognitive processes. This stimulating environment can produce increased learning capacity while also increasing the effort and the quality of individual performance.

The inter-relationship of the small interactive group to motivation, security, social reinforcement, stimulating environment, and the development of personality, coupled with an ability to improve the cognitive quality of verbal interaction, suggests that the small group has important relationships to achievement and learning.

II. EVALUATIVE LITERATURE

While the foregoing descriptive literature appeared to support the thesis that small interactive groups can make valid contributions to achievement and learning, the sources quoted tended to be somewhat generalized since their data was frequently made up of many and varied applications each related in only a small way to the concept involved. To add a background of quantitative studies that are illustrative of the studies done in this field, this section has been added. However, like the descriptive literature, no particular study was noted that applied completely to this investigation.

Much of the evaluative literature encountered was trying to establish the effectiveness of a single "group mind" as compared to an individual mind. The "group" was expected to do something six times as fast, or six times as difficult, for example, than could be done by an individual. In such studies techniques of constructing artificial or "nominal" groups--composites of the production of several individuals--were used in an attempt to compare group versus individual productivity.

The Lorge et al (1958, pp. 337-72) survey of the quality of performance of groups versus the quality of performance of individuals, cited considerable experimentation that had not produced conclusive results.

Studies at Primary and Elementary Grade Levels

A study by Macdonald (1966, pp. 643-46), using 373 subjects, compared a one-to-one tutoring technique with a control method which used small groups without any teacher help. His results showed that tutoring produced significant readiness, but that the control classes receiving no teacher instruction (the grouped students) scored significantly higher in post-test achievement.

A replication type of study by Fredenburgh (1961, pp. 42-45) used grouped and ungrouped children in two fifth-grade spelling sessions of fifteen words for each replication. The teacher instructed the control subjects while the experimental groups were left to make decisions among themselves about learning the word spellings. Both of the experimental and the control classes were pretested and matched. The F-ratio (analysis of variance) was not significant for the first study or its replication, suggesting that the grouped students did not achieve differently from the teacher-taught controls. The children enjoyed the grouping and wished to continue. It is of interest that those with no teacher help--the grouped students--achieved equally with the control students.

A large sample from forty-seven self-contained classrooms in eight elementary schools was used by Durrell (1961, pp. 360-365) to study group teams as compared to traditionally instructed classes. The experimental groups used pupil-team learning plans with materials of a continuous progress type adapted for their use. The control classes did not use these materials but relied upon teacher instruction. Three grade levels were involved, all being tested with Metropolitan Achievement tests for comparisons. After one year of operation the experimental group teams had gained six months of achievement at the grade six level, four months at the grade five level, while there was little difference at the fourth grade. Reactions of the experimentally grouped students were generally favourable.

There appear to be certain limitations in the Durrell study in spite of the large sample used. Of particular note is the difference in materials for the experimental groups as compared to the traditionally taught control classes. Since there was no difference in instruction obvious to the control students, it was possible that the Hawthorne Effect might have been operable in the case of the experimental subjects who were obviously taking part in a different kind of teaching method.

Junior and Senior High School Studies

Higher grade level studies may have trends or results that can be extrapolated to the elementary level and so are included with the related literature.

Anderson (1961, pp. 67-75) tested real and artificial groups of one, two, three, four, and greater numbers of individuals for the purpose of testing the "power of the group mind." The output of each group was compared to the output of the other groups and to the 'pooled' output of the artificial groups which were composed by randomly assigning the output of several individuals. The scores of both real and artificial groups improved as their sizes increased. The findings were in favour of the real-grouped students as compared to the pooled or artificial individuals. The study showed that even the lower achieving members of groups do contribute, and that interaction yielded achievement increments beyond the mathematical sums of the achievement of individuals.

Small Group Studies at the College Level

Most of the small group research suggesting positive interaction effects has been done with college level students. Again, methods of nominal or artificial grouping were used in an attempt to equate achievement in terms of sums of individual minds with "group minds." The small increments resulting from the experimental contributions are more characteristic of studies of achievement and learning.

Wolfgang (1967, pp. 36-40) investigated the effects of social cues and task complexity in "free interaction groups," "restricted interaction groups," and with controls working individually. The free interaction groups were those allowed to plan and work without any instructor interference; the restricted interaction groups received similar information but were not allowed to do certain types of planning and discussion. The study involved a rigorous statistical design using a sample of 120 college males. A high level of significance was found in favour or the free interaction groups on complex tasks. Besides low errors, the free interaction groups scored significantly above the other groups or the control subjects ($p < .005$).

A similar study by Beach (1960, pp. 208-212) tried to establish the effect of sociability upon achievement using the following degrees of social opportunity: control groups--no social opportunity; lecture groups, independent study groups, discussion groups, and small groups on their own--maximum social opportunity. Small groups on their own achieved better than the control groups. The more sociable individuals achieved better in a social setting, while the less sociable individuals achieved more in a less social milieu--such as the lecture group.

Klausmeir, et al, (1963, pp. 160-164) investigated the efficiency of initial learning and transfer by individuals, pairs, and quads. Compared to individuals, the quads showed significantly more complete concept attainment, but individuals were slightly above the quads in terms of later transfer or usage of the concepts. In a replication on the results of transfer, Klausmeir (1964) failed to obtain any significant differences.

A rigorous and careful study by Barnlund (1959, pp. 55-60), using a large sample, compared individual majority and group judgment. By the use of careful balancing and equating procedures he attempted to eliminate groups that were a "function of their strongest members." Group scores were found to be clearly superior to totalled (artificial group) individual decision scores and to the scores that individuals or reshuffled groups could achieve, working individually. In only two out of twenty-nine groups did students working together fail to outperform their own best members.

Summary of Evaluative Literature

Much of the evaluative literature surveyed dealt with the problem of distinguishing between the achievement of a "group mind" compared to an "individual mind." Very few focussed on possible contributions that small group interaction might make to learning or achievement of individuals, and none of the studies used grouping purely in the sense of an administrative device, with individual achievement improvement as the goal. However, the general trend to groups achieving better at more difficult tasks was shown. In addition, there was some suggestion that higher elementary levels benefit more from grouping than do the lower grade levels. There was a definite indication that groups are more than the products of their better members.

CHAPTER III

DESIGN AND PROCEDURES

Throughout the investigation, great care was taken so that any increment, positive or negative, due to small interactive intraclass grouping could not have been produced by the design or the procedures of the study. This chapter explains the experimental design and describes the main procedures involved with the instruction and the testing.

I. DESIGN

Mental ability and socio-economic status were two variables known to have an important relationship to achievement. An analysis of variance (ANOVA) statistical design was chosen to manipulate the effects of these variables while simultaneously computing the effects of the experimental and control treatments. To complement this design, a sufficiently large sample was obtained to distribute or randomize equally, among the control and experimental subjects, the known variables.

Statistical Design of the Study

The ANOVA was designed with three factors--a mental age factor, a socio-economic factor, and the treatment factor.

The treatment factor included two levels of instruction--the experimental, in which classes were divided into several small interactive intraclass groups for instruction; and the control level in which classes received the same type of instruction but without the between-pupil interaction. The variable being tested was this "between-pupil interaction" as generated within the small groups.

The mental age factor was designed to have two levels: a high mental age and a low mental age.

The third factor involved three levels of socio-economic status: high, middle, and low.

The final experimental design might best be described as a 2 x 2 x 3 ANOVA. Table I summarizes the structure of the ANOVA and the contents of the twelve cells.

TABLE I

PLAN OF 3-FACTOR ANOVA SHOWING CELLS

		Experimental (1)	Control (2)
High M.A. (1)	High S. Ec. (1)	1 1 1	1 2 1
	Middle S. Ec. (2)	1 1 2	1 2 2
	Low S. Ec. (3)	1 1 3	1 2 3
Low M.A. (2)	High S. Ec. (1)	2 1 1	2 2 1
	Middle S. Ec. (2)	2 1 2	2 2 2
	Low S. Ec. (3)	2 1 3	2 2 3

Statements of Hypotheses

Although the study was undertaken primarily to investigate the effect upon individual achievement of interactive intraclass grouping, an analysis of Table I shows that information with regard to socio-economic status and mental ability can be considered separately or in combination, with or without the experimental and the control conditions. The hypotheses that were tested by this study are summarized in the "null hypothesis" form:

(a) There is no significant difference between achievement of experimentally taught individuals and those receiving the control instruction.

(b) The experimental instruction produces no significant differences in achievement between higher, middle, and lower socio-economic status students.

(c) The experimental instruction produces no significant differences in achievement between higher and lower mental ability students.

(d) Higher socio-economic status students do not achieve significantly higher in science than do middle or lower socio-economic status students.

(e) There is no significant difference in preference for working in groups or individually between experimentally taught students and control subjects.

Experimental Setting and Sample

Seven schools in suburban and city districts were selected because of the known soci-economic status of most of the parents in the areas served by the schools. This made it possible to more nearly obtain a balanced socio-economic sample.

In each of the seven schools two classes were selected and these were then chosen to be either the experimental or the control group by the flipping of a coin. The starting sample was made up of fourteen classes of approximately 460 students with seven classes of experimental groups and seven classes of control subjects.

Rejection of four students from each of the experimental and the control samples for reasons of a Child Guidance Clinic history--very low I.Q. combined with very low reading scores--reduced the sample by eight. These eight students would not likely have a classification or performance that would be too reliable.

Further attrition of the remaining sample due to illness, patrol duties, doctor appointments, or other typical reasons for absence, reduced the total to 386 subjects, since the missing of only one portion of any one lesson or test resulted in that student's test information being invalid in a total measure design.

A random casting-out procedure was used to remove subjects from the control sample for the purpose of producing approximately equal numbers in each of the twelve cells of the ANOVA as is usually required for computational purposes. Such adjustments removed only thirty-three subjects and the balance was maintained with regard to boy-girl ratio, mental age, and socio-economic distributions. Table II, below, shows the final number in each of the cells according to sex, mental age, and socio-economic status.

TABLE II

COMPOSITION OF ANOVA CELLS BY: SEX, MENTAL AGE, AND BY SOCIO-ECONOMIC STATUS

Cell M E S	Ex. or Control	N	Mental Age		Boys		Girls		Soc. Ec.		
			Hi	Lo	Gr.	Con	Gr.	Con	Hi	Mid	Lo
1 1 1	Ex.	30	30	--	16	--	14	--	30	--	--
1 1 2	Ex.	35	35	--	16	--	19	--	--	35	--
1 1 3	Ex.	24	24	--	15	--	9	--	--	--	24
1 2 1	Con.	33	33	--	--	18	--	15	33	--	--
1 2 2	Con.	23	23	--	--	12	--	11	--	23	--
1 2 3	Con.	29	29	--	--	15	--	14	--	--	29
2 1 1	Ex.	21	--	21	11	--	10	--	21	--	--
2 1 2	Ex.	31	--	31	19	--	12	--	--	31	--
2 1 3	Ex.	30	--	30	19	--	11	--	--	--	30
2 2 1	Con.	27	--	27	--	12	--	15	27	--	--
2 2 2	Con.	28	--	28	--	17	--	11	--	28	--
2 2 3	Con.	34	--	34	--	24	--	10	--	--	34
TOTALS:		345	174	171	96	98	75	76	111	117	117

The frequency distribution comparison between the experimental and control samples for mental age is shown in Table III, on the following page. Mental ability was considered to be the most significant variable likely to affect or obscure achievement results since its ANOVA F ratio was greatly significant.

TABLE III

MENTAL AGE DISTRIBUTIONS OF THE EXPERIMENTAL AND CONTROL SAMPLES - SHOWING DISCARDS

	Treatment Sample		Control Sample	
Int.	Final f	Discard	Final f	Discard
195-199	0		1	
190-194	3		2	
185-189	4		3	
180-184	6		10	
175-179	11		5	
170-174	13		14	
165-169	19		21	4
160-164	18		23	5
155-159	23		22	
150-154	27		25	3
145-149	15		16	11
140-144	14	(1)*	12	10
135-139	11	(1)*	11	
130-134	3	(1)*	4	
125-129	1	(1)*	4	(1)*
120-124	3		1	(1)*
115-119	0		0	(2)*
TOTAL:	N = 171	(4)	N = 174	(37)
	MEAN = 157.85		MEAN = 157.84	

(* Unreliable reading score + Low I.Q. + Clinic History)

During the experiment no attempt was made to counteract changes in the sample for reasons of student absence. Since illness and special duties were random factors affecting the experimental and the control samples with equal probability, the attrition was assumed to have little effect upon the investigation's findings.

The Science Measure and Reliability

Three instructional periods were each followed by their separate post-test. However, the test results were totalled to yield one final science measure. Each test item was of the multiple choice type, and, where practical, was made as pictorial as possible to reduce the verbal demands on sixth grade children. Copies of the test are included in the Appendices.

Each of the objective items of the tests was designed to measure one of the specific responses that might reasonably be expected from the experiences of the children with the material during the science lessons. Each of the three tests required more than ten minutes of time for individuals of an average class at the grade six level. This time limit and the difficulty level of some of the items allowed scope for brighter students. Sufficient numbers of easy items were supplied to give even the slowest students some measure of success in the ten minutes of testing at the end of each instructional period.

Individual answer booklets provided a convenient and uniform means to collect and record student replies as well as to obtain the necessary personal information from the students and from the school records.

Scoring was easily and quickly done by means of a transparency overlay. The see-through technique made it possible to count all questions attempted so that calculations could be made for chance using the $R - \frac{1}{4} W$ formula.

The three tests were designed by the investigator since a lack of appropriate and specific short measures of science achievement made it necessary to improvise. These three tests were combined for the purpose of obtaining a reliability coefficient. The Kuder-Richardson and Hoyt analysis of variance method indicated a reliability coefficient of 0.70. This was considered a high reliability coefficient and meant that the test was accurately measuring some characteristic of the people taking it, and that the test items were homogeneous (Bruning and Kintz, 1968, p. 119, pp. 188-91).

Attitude Inventory or Enjoyment Scale

While not being pertinent to the statistics as related to achievement, information about the affective response of the subjects to the experimental and control instruction was very relevant to further use or involvement of the interactive intraclass group mode of instruction. For this reason, and to gain other information that might have implications for further studies, an attitude inventory was administered to the experimental and the control groups.

The inventory was a seven-point scale with choices worded in such a way as to have the positive feelings for "groups" at one end of the scale and to have positive feelings for private or "individual" work methods at the other end of the scale. Neutral or unhappy feelings were checked at the centre of the scale. (Appendix G). The inventory was administered after every lesson, thus yielding three replies that were assumed to be less subject to random choice, to inconsistency, or to hasty decision-making, than would be the case if the scale were used only once.

II. PROCEDURES

Each of the three lessons employed discovery techniques using supplied materials. The materials were deliberately used for three purposes: to minimize the teacher variable by eliminating the teacher as a data source; to provide interest and motivation; and to provide a non-cultural, non-verbal, and equally available data source. Thus all students had equal access to the information necessary to solve the problems or to attain the expected objectives. Teacher-training involvement made it desirable that methods should demonstrate both the use of simple, low-cost, easily maintained equipment, together with the concept that pupils could solve problems and reach conclusions using materials-based discovery lessons.

Variables and Controls

In addition to the variables accounted for in the ANOVA plan--mental age and socio-economic status of the child--other variables were either controlled or were randomized by distribution throughout all levels of both the experimental and the control samples.

Boy/Girl ratio. The distribution of scores by sex is shown in Table IV on the next page. An almost identical boy/girl ratio was obtained for each of the two samples (1.280 as compared to 1.288 for the experimental and the control samples, respectively). This ratio was obtained from the information given in Table II, on page 39, which shows the boys and girls for each cell and the total for each of the experimental and control samples. The difference between the boys' achievement mean of 18.46 and the girls' achievement mean of 18.62, suggests that this variable should not appreciably contaminate the results of the investigation.

Instructional variable. Uniform procedures and the same instructor throughout the investigation were used in an attempt to minimize the instructional variable. The pupil-discovery, non-intervention teaching approach freed the children to obtain answers primarily from the materials.

If interaction produced a higher achievement score, such increase had to take place during the timed portion of the lessons. In large classes a certain amount of interaction would occur that was detrimental since the instructor

TABLE IV

DISTRIBUTION OF SCORES BY SEX

Interval	Frequency	
	Boys	Girls
39 - 41	0	1
37 - 39	3	0
33 - 35	3	5
30 - 32	4	9
27 - 29	10	12
24 - 26	21	13
21 - 23	34	19
18 - 20	41	24
15 - 17	25	24
12 - 14	18	15
9 - 11	18	13
6 - 8	13	12
3 - 5	1	4
0 - 2	3	0
MEANS:	18.46	18.62

could be neither a perfect judge nor an instantaneous reverser of negative roles. If the interaction yielded positive results the bias was certainly in favour of the control subjects, since they did not always restrain their interaction with their neighbours.

Interaction of a visual nature could also take place at a considerable distance. In the control classes each individual could see others working. Shields or private working stations would be necessary to control this "group" effect.

Normally, students working individually would tend to ask questions individually and to be answered individually while groups would tend to ask and to be answered to as groups. A bias in favour of grouping might have occurred if the investigator had been giving helpful advice and instructions, since six people would receive advice simultaneously in a group while only one person would receive information from the same type of interaction in a one-to-one exchange. For this reason instructions or corrective measures were announced to the whole class, but helpful instruction was avoided in favour of neutral answers such as: "I'm sorry, I'm not allowed to help today,"---"What do you think?"

The influence of the previous teacher was nearly always equal for the experimental or the control classes, since in almost every school the two classes selected were taught by the same teacher. This modified departmentalization in which certain teachers were teaching all the science at the grade six level existed in all but one school. The rearrangment of pupils from all the schools throughout all the ANOVA cells would likely minimize the effect in the case of the one school that was not departmentalized.

Previous knowledge and experience. At the outset of each lesson students were asked simple, short questions, which, had they been able to answer, would have indicated previous familiarity. Almost no key knowledge was shown. In the third lesson, for example, the words "cylinder" and "sphere" occurred. Invariably these had to be explained. The second lesson was originally planned on the assumption that grade six students would have had some quanititative background for simple balances. This proved not to be the case, so the simple "moments" concept was incorporated as a regular part of the lesson.

Equipment variable. The nature of the science lessons used in this investigation was influenced by the type of equipment that could be supplied, economically, in sets, for thirty-six students, simultaneously. While two of the lessons were modelled after Piaget's "Operations of Exclusion" (Inhelder and Piaget, 1958, pp. 67-79), materials that were easy to transport, set-up, dismantle, and that could give quantitative results, and also withstand repeated student usage, limited the study of other facets of science at this time.

The equipment variable was biased in favour of the control sample. Each control individual received one set of equipment whereas each four-to-six (or seven) member group received only one set per group. Occasionally, the six or seven member groups, because of awkward seating arrangements due to desk size or shape, were supplied with two sets of equipment. The extra sets were given out when it became apparent that the distance of the isolated members was causing them to lose interest. The assumption was made that supplying equipment would motivate, reward, and supply answers; rather than act detrimentally. There was the possibility that difficulties encountered individually with regard to manipulation could cause negative effects. If such a problem occurred in a group, it would be solved by any member with the necessary skill.

A description of the materials and their usage is provided in Appendix O. The first lesson required students to exclude or confirm the variables that effected the period of a pendulum. The second lesson required the students to discover the quantitative relationship involved with a simple balance, and to extend this to a more complicated "moments" rule, if possible. The third lesson required the students to classify a set of ten miscellaneous objects using a coding key. This classification was recorded on punched cards. These cards were then used to identify the objects, given brief sets of their properties.

Other variables. Other variables, especially readiness and reading ability, were presumed to be distributed throughout both the experimental and the control samples. No attempt was made to control them by any other method. As a precaution, reading test scores were collected for all subjects in the investigation. The mean grade rating for both the experimental and the control samples was almost identical for each (approximately at the 7.5 grade level). As previously mentioned, eight students with extremely low reading scores coupled with very low I.Q. ratings, and who also had Child Guidance Clinic histories, were withdrawn from the investigation as not likely to produce or obtain reliable test scores on group tests.

Reading was eliminated as much as possible from the administration procedures by making sure that all the directions for doing tests and working with lesson materials were given verbally in addition to the written hand-outs.

Instruction and administration. The instruction and the administration procedures were kept to a minimum. The investigator came into the classroom, briefly introduced the topic, handed out the activity instructions, elicited student help to hand out equipment, went over the instructions verbally, demonstrated apparatus set-ups, and then left the class to work on the posed problem. The investigator then circulated among the students or the groups with the purpose of providing help unrelated to the problem.

Students were given about twenty minutes to attempt or to discover the solutions to the problem, then equipment return was initiated. Post tests and booklets for receiving the answers were handed out. Directions were repeated verbally, using blackboard illustrations where clarity could be improved, then students were given ten minutes to do the post test. At the end of the allotted time booklets and test papers were collected. The second and third lessons followed the same pattern The same answer booklets were used for the three tests. This repeated use of the same booklet provided a familiar pattern for the student replies and also made it possible for students to provide personal information omitted during the first administration.

The experimental classrooms required one additional set of instructions--directions for moving into groups of four to six students.

After the demonstration of the materials the goal for the lesson was usually quite obvious. More questioning was encountered in the control classes in which student interaction was restricted. The experimental groups always seemed to need less instructor help. It was assumed that the groups were able to supply their own answers to the questions raised by slower students or by those who may not have paid attention. During the timed portions of the lessons, teacher help was merely facilitative, consisting mainly of assistance to the few who were unable to get their apparatus functioning at the beginning of the period. Normally, the instructor had little to do during the timed lessons, as would be expected when the materials were to be the source of answers to the lesson problem. After it became obvious the instructor was not going to answer questions, and students realized that the materials were provided for this purpose, very little attempt was made to obtain instructor intervention.

Information from the school records was collected only for those students who had successfully completed all three tests. The booklets that were without the minimum required information were withdrawn from the sample.

The total information was then summarized--mental ages, I.Q.'s, chronological ages, socio-economic status, reading levels, individual test scores (corrected and also uncorrected for guessing). Coded numbers for pupils and their schools were then assigned and added to the summary. This information was then analyzed using the computer program available at the Computing Centre of the University of Manitoba.

Analysis of data. All tests used five-item multiple choice questions. Scoring was objective, and a correction for chance or guessing was made using the "$R - \frac{1}{4} W$" formula. The scores of these three science post tests were combined into one total measure for the statistical treatment, with each individual subject having one combined test score.

The classification of both experimental and control subjects into a High or Low mental age category was achieved by dividing the whole sample at the mean I.Q. value.

The three level division of the subjects into a High, Middle, and Low, socio-economic status was made using the Blishen (1958, pp. 519-531) "Occupational Class Scale." Using his seven classes, Class One and Two subjects were designated as High; Classes Three, Four, and Five, were designated as Middle; while Class Six and Seven subjects were allotted a Low classification.

The Canadian population in 1951 was listed as having eleven per cent in Classes One and Two of the Blishen scale; forty-eight per cent in Classes Three, Four, and Five; and forty-one per cent in Classes Six and Seven combined (Porter, 1965, p. 163). Since the population of the experimental and the control samples was taken so as to allow approximately thirty-three per cent in each socio-economic level, the population of the investigation does not represent a true distribution of all occupations in Canada at that time.

After the experimental and control samples were divided into the high-low mental age classification and these levels were further divided into the high-middle-low socio-economic classification, the analysis of variance was utilized to give within and between group variance comparisons. These comparisons were tabled as "F-ratios" and were tested for significance.

All comparisons for F-ratios that were found to be significant were then used as a guide to subject the mean scores of the various factors and levels to a Duncan's Multiple Range "t" test for estimations of the significance of the differences between these mean scores for the experimental and control samples in the levels in which significance was found.

The attitude inventory scores were analyzed using the Chi-square Median test. This enabled a test for significance to be made for the differences of the mean scores as obtained by the experimental and control samples.

CHAPTER IV

PRESENTATION OF FINDINGS

The results from the analysis of variance and of the t tests for significance among the differences between means are the main basis for the findings and the interpretations of this chapter. Also presented and interpreted are the findings from the Chi-square median test using the scores on the attitude inventory. In addition to these are three other analyses. The post test scores were separated into the scores for each lesson and each of these test results were analyzed separately in an attempt to more precisely locate the type of lesson that contributed most significantly to the findings.

I. ANALYSIS OF COMBINED TEST DATA

The high and low mental ability factor, and the high middle, and low, socio-economic factor, in the ANOVA design, coupled with the experimental and control categories made it possible to consider the effect of the experimental grouping upon high or low mental age students, or upon high, middle, and low, socio-economic status students. At the same time, the method of analysis also made possible an estimation of the effect of the experimental grouping as compared to the control achievement without relation to either of the mental age or socio-economic factors. This next section is concerned primarily with the experimental and the control achievement comparisons.

<u>Findings Related to Experimental and Control Achievement</u>

The F values for the experimental factor and interaction of the experimental treatment with the mental age factor are given in Table V. The F value for the experimental factor was 5.90, and the F value for the interaction of the experimental factor with the mental age factor was 5.41. Both F ratios were significant beyond the .025 level. These significant F values indicated that greater variances were obtained between factor levels than were found within levels, thus suggesting that the between level variances would not likely be produced by chance alone.

TABLE V

SUMMARY OF F VALUES FOR EXPERIMENTAL AND CONTROL ACHIEVEMENT RESULTS USING THE SINGLE SCIENCE MEASURE

SOURCE	DF	SS	MS	F	p
Experimental	1	252.33	252.33	5.90	$<.025$
M.A. x Experimental	1	231.71	231.71	5.41	$<.025$
WITHIN CELLS	333	--	42.80	--	--

The results of the analysis of the differences between means, using Duncan's Multiple Range Test, are found in Table VI on page 57. The means of the experimental factor were 19.39 and 17.68 for the experimental and the control achievement, respectively. The difference, significant at the .05 level, was in favour of the achievement by the experimentally grouped sample. Similarly, at the high mental age level, the interaction effects of the experimental and the mental age factors yielded means of 22.84 and 19.49 for the experimental and the control subjects' achievement, respectively. This difference was significant at the .01 level. No significance was found for differences between the means at the low mental age level.

In the interaction between the experimental factor and the socio-economic status factor, the mean of the experimental subjects' achievement was 21.41, compared to 18.59 for the control achievement. The difference was significant at the .05 level, and was obtained only for the high socio-economic status level.

No significant mean-differences were found at the middle and low socio-economic status levels with regard to the experimental or the control achievement results.

These results indicated that there were significant achievement differentials produced by the experimental interactive intraclass grouping, but these differentials tended to be associated with high mental ability or high socio-economic status students.

The hypothesis of no significant difference between the experimental intraclass group achievement and of the achievement of the control individuals was rejected at the .05 level.

TABLE VI

COMPARISONS OF MEANS AND PROBABILITIES FOR EXPERIMENTAL AND CONTROL ACHIEVEMENT

SOURCE	N	MEAN	p
Experimental Factor			
Experimental	171	19.39	< .05
Control	171	17.68	
Exper. x Mental Age			
Exper. x High M.A.	89	22.84	< .01
Control x High M.A.	85	19.49	
Exper. x Low M.A.	82	15.94	n.s.
Control x Low M.A.	89	15.87	
Exper. x Socio-Economic			
Exper. x High S. Ec.	51	21.41	< .05
Control x High S. Ec.	60	18.59	
Exper. x Mid. S. Ec.	66	19.35	n.s.
Control x Mid. S. Ec.	51	18.30	
Exper. x Low S. Ec.	54	17.22	n.s.
Control x Low S. Ec.	63	16.16	
TOTAL SAMPLE	345	18.54	

The hypothesis of no significant difference between the experimental intraclass group achievement and that of the control individuals' achievement for higher or lower mental ability students was rejected at the .01 level for the higher mental ability students, with no significant difference between the achievement of the experimental and the control subjects at the lower mental ability levels.

The hypothesis of no significant difference in achievement between the experimentally grouped and the control subjects was rejected at the .05 level for the high socio-economic status students, with no significant difference being noted for the middle and lower socio-economic level subjects. While the differences were not significant at the middle and lower socio-economic levels, it should be noted that a definite trend in the means was shown. This trend favoured the experimental grouping at both the middle and the low socio-economic levels.

Socio-Economic Status and Achievement Findings

In addition to studying the effect of the interactive intraclass grouping upon grade six science achievement, information about the effect of socio-economic status on science achievement was also sought. The ANOVA was designed to supply this additional information.

The F value for the socio-economic factor was 7.09. This was significant at the .01 level, indicating that there were significant differences likely to be found among the means related to high, middle, and low socio-economic status. The F values for the socio-economic factor and its interactions are shown in Table VII.

TABLE VII

SINGLE SCIENCE MEASURE F VALUES FOR SOCIO-ECONOMIC STATUS

SOURCE	DF	SS	MS	F	p
Socio-Economic	2	606.97	303.49	7.09	<.01
S. Ec. x Exper.	2	53.36	26.68	0.62	n.s.
S. Ec. x M.A.	2	241.17	120.58	2.82	n.s.
WITHIN	333	--	42.80	--	--

The means of the three levels of the socio-economic factor were 20.00, 18.82, and 16.79, respectively, for the high, middle, and low status subjects' achievement scores. Between the high and the middle, the difference was not significant, but between the middle and the low, the difference was significant at the .05 level. The difference between the highest and the lowest was significant at the .001 level. Since the ANOVA computations gave this socio-economic status information without involvement of the mental ability and the experimental treatment factors, it must be assumed that socio-economic status did effect science achievement. This effect was greater between the middle and the low socio-economic levels. The socio-economic factor means and the levels of significance for their mean differences are shown in Table VIII.

TABLE VIII

COMPARISONS OF ACHIEVEMENT MEANS AND PROBABILITIES FOR HIGH, MIDDLE, AND LOW SOCIO-ECONOMIC STATUS

SOURCE	N	MEAN	p
Socio-Economic Factor			
High	111	20.00*	n.s.
Middle	117	18.82	<.05
Low	117	16.79	<.001
		*(20.00)	
TOTAL SAMPLE	345	18.54	

The hypothesis of no difference in achievement among the high, middle, or low socio-economic status students was thus rejected at the .05 level between the middle and low status students, and at the .001 level between the highest and the lowest socio-economic categories.

From this, it would appear that there was greater difficulty for the lower socio-economic status students to achieve in science than for their higher socio-economic status peers. This difference was more marked between the low and the middle status students than it was between the middle and high socio-economic status levels.

II. ANALYSIS OF INVENTORY RESPONSE

The students of the experimental intraclass grouped sample and the control individuals recorded preferences on a seven-point inventory. This scale was designed to discover if there were any marked feelings about working in groups or if there were, instead, preferences for working privately and individually.

Findings Related to the Attitude Inventory

Table IX, page 62, shows the distribution of choices by pupils with regard to preference for working in groups or for working individually. The choices were made on a twenty-one point scale derived from the possible combinations that arose when a one-to-seven point scale was administered three times and the results were added. (If a student chose item "5" for lesson one, item "6" for lesson two, and item "2" for lesson three, his total on the twenty-one point scale would be "13.") This method was preferred to the method of computing averages. The inventory description is given in Appendix G.

The experimental pupils obtained a mean of 16.22 while the control sample mean was 12.21. The mean for the combined sample was 14.20. A Chi-Square median test was used to compare the choices of the two groups. (The obviously non-normal distributions suggested non-parametric test usage). A two-by-two contingency table was arranged as shown in Table X on page 63. The value of the median was 14.96.

TABLE IX

FREQUENCY DISTRIBUTION SHOWING THE GROUP-INDIVIDUAL PREFERENCES OF EXPERIMENTAL AND CONTROL PUPILS

Interval	Frequency	
	Experimental	Control
21	14	4
20	4	1
19	9	1
18	51	17
17	16	6
16	13	8
15	27	26
14	8	10
13	8	12
12	7	19
11	4	15
10	2	2
9	5	19
8	0	4
7	1	4
6	1	15
5	0	6
4	0	1
3	1	4
	N = 171 Mean = 16.22	N = 174 Mean = 12.21
MEAN FOR TOTAL SAMPLE = 14.20		

The calculated Chi-square value was 59.25. For one degree of freedom, this was significant beyond the .001 level.

TABLE X

MEDIAN TEST CONTINGENCY TABLE FOR ATTITUDE INVENTORY

SOURCE	Below Median	Above Median	TOTALS
Controls	125	49	174
Experimental	51	120	171
TOTALS:	176	169	345

$\chi^2 = 59.25$, df = 1, $p < .001$

The hypothesis of no significant difference between the choices of the experimental and the control pupils, in terms of preference for working in groups as compared to working privately and individually, was rejected.

An analysis of the choices in terms of these findings showed that students who participated in small interactive intraclass groups significantly more often selected responses at the like-to-work-in-groups end of the scale. Their most frequent response was for item number six. This was shown by the mode of eighteen on the twenty-one-point scale. Item six states: "Working with others was the part of the lesson that I liked best since I do not enjoy working by myself." Figure 1, page 64, illustrates the frequency response variations of the experimental and control samples.

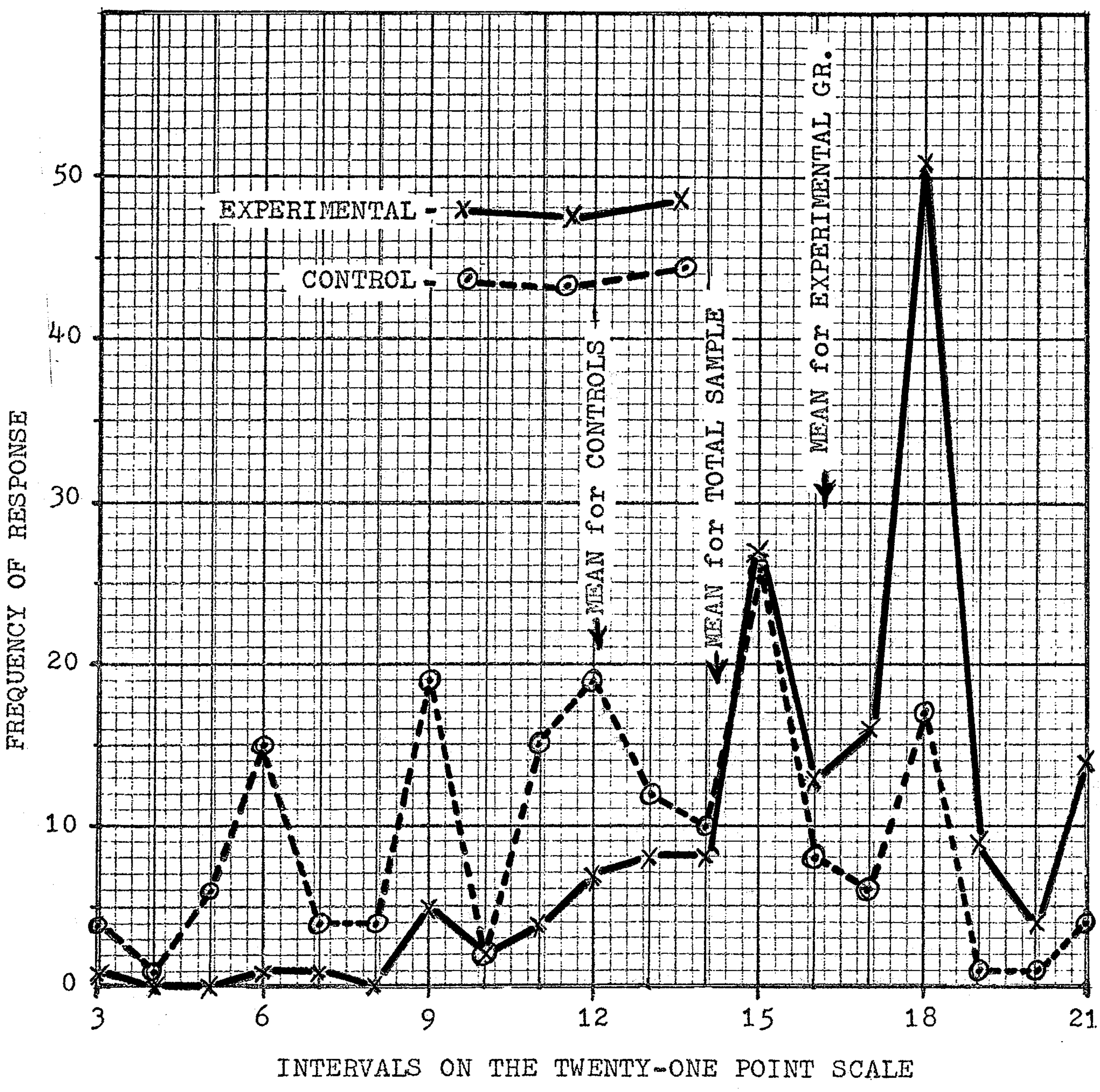

FIGURE 1

DISTRIBUTION OF PREFERENCES ON THE ATTITUDE INVENTORY
BY CONTROL AND EXPERIMENTAL PUPILS

The students who worked individually in the control classrooms did not choose in such a manner as to register responses at either end of the scale. Their mean on the twenty-one point scale was 12.21. Translated in terms of the seven-point inventory, this suggested that their choices were at the neutral or central position. In actual fact, very few chose the middle item on the original seven-point scale. The "12" value on the twenty-one point scale merely represents an average computed from items chosen on either side of the central position. The mode for the control subjects was at number fifteen on the twenty-one point scale. Interpreted, this was number five on the seven-point inventory which stated: "If I had the choice, I think I would try again to work with a group during science lessons."

For this type of inventory, the <u>expected</u> mean would normally be twelve for both samples. This was almost precisely the result shown by the control sample's choices. However, the experimentally grouped subjects chose the like-groups end of the scale more frequently than the individually working controls chose the like-to-work-individually end of the scale. This definite trend--avoiding private individualized science instruction while having a strong preference for being in small group situations whenever possible--may have important motivational and mental health implications.

III. OTHER ANALYSES OF TEST DATA

ANOVA's of the three post tests, taken separately, were computed in an attempt to assess the type of lesson that contributed most to the achievement of the experimental groups and, to answer questions related to the effects of tests being corrected for guessing or chance, the total science measure was subjected to an analysis of variance a second time, but with the scores not corrected for guessing. This section presents the findings related to these four ANOVA's.

Findings Related to the Separated Post Test Data

For each test the F value for mental age was significant beyond the .001 level. For some reason there was a drop in the mental ability F value for test number two. This was the test considered by most students to be the most difficult. The F values were 21.76, 12.74, and 33.60, respectively, for the pendulum, law of the balance, and the classification tests.

For the pendulum test, the socio-economic factor's F value of 4.95 was significant at the .05 level and for the law of the balance test, the F value was 5.83. This latter was significant at the .025 level. The mental ability interaction with the experimental treatment was significant at the .05 level in the classification lesson with an F value of 4.41. The F values and the probabilities obtained using Duncan's Multiple Range test procedures are summarized in Table XI on the next page.

TABLE XI

ANALYSIS OF TEST SCORES FOR LESSONS ONE, TWO, AND THREE

SOURCE	DF	SS	MS	F	p
# 1 - Pendulum					
Mental Age	1	472.51	472.51	21.76	<.001
SocioEconomic	2	214.92	107.46	4.95	<.05
# 2 - Balancing					
Mental Age	1	114.56	114.56	12.74	<.001
Experimental	1	52.43	52.43	5.83	<.025
# 3 - Classification					
Mental Age	1	256.66	256.66	33.60	<.001
M. A. x Experiment.	1	33.69	33.69	4.41	<.05

In the second lesson there was some aspect of the law of the balance that definitely favoured the experimental grouping, but which did not favour the mental age variable to the same extent as did the first and third tests. For all classes the second lesson appeared to be the hardest and most frustrating of the three lessons, as evidenced by some of the less able students who showed restlessness and a readiness to stop even before the announced time limit.

Total Measure Scores Not Corrected for Chance

Some experts differ in their opinions with regard to correction of multiple choice tests for guessing or chance. As a precaution another ANOVA was computed for the original mental age and socio-economic information, but with the achievement scores for all subjects not corrected for chance or guessing. Table XII, page 69, shows analysis results for only the factors or interactions having significant F values. By comparing these values with previously noted information (Tables V and VII, pages 55 and 59, respectively), the effects of correcting for chance can readily be discovered.

For the experimental factor, corrected for chance, the F value was 5.90. Without the correction for chance the F value was 7.04. The level of significance changes from .025 to .01 in favour of the tests not corrected for chance. The corrected for chance socio-economic F value was 7.09 which was significant at the .01 level. The correction for chance increased this F value from 5.99 with significance at the .025 level. The mental age F value was reduced from 55.87 to 50.65 by the correction for chance or guessing.

TABLE XII

ANALYSIS OF SCORES NOT CORRECTED FOR CHANCE OR GUESSING

SOURCE	DF	SS	MS	F	p
Mental Age	1	1661.01	1661.01	50.65	$<$.001
Experimental	1	230.82	230.82	7.04	$<$.01
Socio-Economic	2	393.97	196.49	5.99	$<$.025
M. A. x Exper.	1	225.18	225.18	6.87	$<$.01
WITHIN CELLS	333	--	32.80	--	--

The interaction of the mental age and experimental factors had an F value of 5.41 when corrected for chance. Without correction, the F value was 6.87. The latter had a level of significance of .01 as compared to a level of .025 when corrections for chance were used.

A much lower 'within cells variance' of 32.80 was obtained on the uncorrected for chance scores. The corrected for chance within cells variance was 42.80. A comparison of these two values suggested that there was more consistency among the scores in each cell of the ANOVA that used scores that were not corrected for chance.

Appendix F lists the means for the scores of both the corrected and the uncorrected-for-chance test results for all cells of each factor. The correction for chance lowered the higher scores about four points and reduced the lower scores about six points. This acted to increase the spread between the top and the bottom scores by approximately two points.

The correction for chance acted to penalize the poorer students, since they had more wrong answers as used in the computational formula $R - \frac{1}{4} W$. The item analysis (given in Appendix A) shows the consistency with which students did NOT obtain correct answers to certain items on the total measure. This suggested that guessing was not a large contributor to the test totals, otherwise these questions would have had a larger quota of "guessed" RIGHT answers. Instead, such questions appeared to have been responsible for many students choosing a particular wrong answer, but not a random or chance wrong answer. If this was so, the higher F value for the experimental factor, calculated using scores not corrected for guessing, suggested that students in the experimental interactive groups may have been penalized somewhat by the correction for guessing or chance.

CHAPTER V

SUMMARY AND CONCLUSIONS

In the foregoing chapter the more significant findings tended to be somewhat obscured by the organization that was necessary for an experimental design which used an analysis of variance with three factors and seven levels. This chapter is designed, therefore, to bring findings more sharply into focus. Where appropriate, possible contributions to achievement, learning, and teaching are stressed.

I. SUMMARY

The Problem and Its Importance

This investigation was designed to answer three different questions about grade six science instruction. The first and major problem of the study was concerned with a comparison of achievement of students instructed in small interactive intraclass groups with the achievement of individuals who received instruction that allowed them to work independently and privately. The experimental treatment was interacted with two levels of mental ability and three levels of socio-economic status of the students involved.

The second problem of the study dealt with an investigation of the effect of socio-economic status upon science achievement without regard to either type of instruction. The third problem was involved with an attempt to discover student feelings about, or reactions to, the two methods of instruction.

The rationale for this study was based upon three concepts: (1) an interactive group is able to supply both a stimulating environment for learning and a prompt feedback or operant learning condition; (2) groups, according to recent research, are necessary to provide individuals with the conditions of minimal anxiety and maximum security particularly required for behavior change learning; and (3) positive group climates, in addition to meeting social-emotional needs and developing personality, may motivate individuals, thus producing better cognition.

In terms of achievement and learning, these concepts are important because motivation, improved cognition, valuing, and other affective responses, complemented by good mental health, are all necessary to the long term goals of education.

Design and Procedures

The experimental design consisted of a three-factor analysis of variance, with high and low levels in a mental age factor; high, middle, and low levels in a socio-economic factor; and experimental and control levels in the third factor. The experimental level included all subjects who worked in small intraclass groups during three science lessons while the control level was made up of classes of pupils receiving similar instruction, but who worked individually and independently.

The sample of 345 subjects, with 171 in the experimental classes and 174 in the control classes, was balanced for mental age, boy/girl ratio, reading level, grade level, and for socio-economic status.

Variables not manipulated in the analysis were controlled as much as possible by administrative procedures. Variables not controlled by procedures were presumed to be distributed throughout all levels of the ANOVA, and were thus randomized among the experimental and control samples.

The instructional variable was kept uniform by a method of instruction that used materials rather than the instructor as a source of information, and which required students to make their own discoveries.

Three science lessons were given. Each was followed by a post test. The three post tests were combined into one single science measure for use in the analysis. This instructor-made "total measure" had a Kuder-Richardson and Hoyt coefficient of reliability of 0.70, signifying that the test was quite reliable. The instruction and test segments of the lessons were timed for all classes.

An attitude inventory, using a seven-point scale, was administered after every lesson. The resulting three scores were totalled rather than averaged. This produced a wider range for the statistical handling of student replies.

Summary of Findings

The findings, summarized in terms of the restated hypotheses, are based upon the results of the ANOVA, Duncan's multiple range testing of mean differences, and the Chi-square median test as used with the inventory.

Hypotheses I. The hypothesis is restated as follows:

There is no significant difference between achievement of experimentally taught individuals and those receiving the control instruction. (p. 37).

The hypothesis was tested by consideration of the ANOVA F value and, further, by testing the differences among the means of the achievement scores of both the experimental and control samples. The F value for the treatment factor was statistically significant at the .025 level. The difference between the two means was significant at the .05 level. The hypothesis was rejected in favour of the experimentally grouped pupils.

Hypothesis II.

The experimental instruction produces no significant differences in achievement between higher, middle, and lower socio-economic status students (p. 37).

The hypothesis was tested using Duncan's multiple range tests of the differences among the means of the levels of the 'Experimental x Socio-Economic' interaction factor. At the high socio-economic level the experimental groups' achievement exceeded that of the control individuals by a difference that was statistically significant at the .05 level. The hypothesis was rejected only at the high socio-economic level.

Hypothesis III.

The experimental instruction produces no significant differences in achievement between higher and lower mental ability students (p. 37).

The hypothesis was tested by consideration of the ANOVA F value for the Mental Age x Experimental interaction factor and of the Duncan's mean difference testing. The F value was significant at the .025 level. The mean difference for the high mental ability level was significant at the .01 level in favour of the experimental groups. Almost identical achievement was found for the two treatment samples at the lower mental ability level. The hypothesis was rejected only at the high mental ability level.

Hypothesis IV.

Higher socio-economic status students do not achieve significantly higher in science than do middle or lower socio-economic status students (p. 37).

This hypothesis was tested by the same method as used for hypothesis I. The factor F value was statistically significant at the .01 level. The differences among the means were significant only between the middle and the low socio-economic status students, with a level of significance of .05 in favour of the middle status student achievement. The achievement of the high status students exceeded the achievement of the low status students by a difference significant at the .001 level. The hypothesis was rejected for the middle and the low socio-economic status pupils, and for the high and the low socio-economic status students.

Hypothesis V.

There is no significant difference in preference for working in groups or individually between experimentally taught students and controls (p. 37).

This hypothesis was tested using a Chi-square median test for the significance of the difference from a median. The experimentally grouped students preferred their method of instruction to a significantly greater extent than the individually working students preferred the private individualized work opportunity. The level of significance was beyond the .001 level. The hypothesis was rejected.

Discussion. A generalized summary of the findings is given below:

(a) The experimental grouping produced statistically significantly greater individual science achievement at the grade six level than was produced by independent work methods of the control individuals

(b) The experimental grouping produced significantly greater individual science achievement at the higher socio-economic level than at the middle and lower socio-economic status levels. The means of the experimental subjects were higher in all cases.

(c) The experimental grouping produced significantly greater achievement with higher mental age students while almost identical achievement was observed for the two treatments at the lower mental age level. The means of the experimental subjects were higher in all cases.

(d) Higher and middle socio-economic status produced greater achievement in grade six science than did low socio-economic status.

(e) A greater portion of the whole sample showed a preference for group work than chose to work individually and privately. The pupils who experienced interactive grouping were generally in favour of continuing the experience, whereas pupils who worked privately and independently were more neutral in their choice of instructional method.

(f) The law of the balance was the science task that most favoured the experimental groups. While this lesson appeared to be the most difficult and frustrating for all students, it seemed to produce more difficulty for the high mental ability students than did the other two lessons.

II. CONCLUSIONS

The foregoing findings strongly support the conclusion that small interactive intraclass grouping is capable of producing, for individuals, increments of achievement that are equal to or better than those produced for individuals by independent or private study methods. These achievement differentials are more marked with higher mental age or with higher socio-economic status students. At the lower mental ability or lower socio-economic levels the achievement was almost identical for the control and experimental subjects. This similar achievement indicates that intraclass grouping need not be avoided at the lower mental ability or lower socio-economic levels.

With regard to the affective, the cognitive, and possibly the psychomotor domains, there is enough evidence to warrant further investigation. Possible long-range contributions to learning in terms of motivation and more positive mental health are certainly indicated by student preferences for social involvement in some of their instructional sessions.

It should be kept in mind that the foregoing conclusions were based upon findings derived from grade six students doing three materials-oriented discovery science lessons and may not be generalizable to other areas of study or to different student levels. Differences in achievement between experimental and control instruction were those produced by only three short science lessons.

III. IMPLICATIONS FOR FURTHER RESEARCH

The findings of this study suggest a number of areas that might be productively explored:

(a) The effect of interactive intraclass grouping as an alternative to independent private study needs further investigation using a range of grade levels and other types of subject matter.

(b) Further study should be made regarding the reasons for lower or higher achievement differentials that result when intraclass grouping is used with lower or higher mental ability and socio-economic status students, respectively.

(c) A replication of this study with year-long instruction would provide more definitive conclusions concerning the total yearly achievement gains likely to be produced. This would allow use of much more extensive pre and post testing in a broader range of learning.

(d) A careful laboratory study using matched pairs might be made to compare the achievement of individuals, isolated by means of private independent work areas, to the achievement of individuals doing the same work in interactive groups, both samples using modified teacher direction and administrative organization typical of open area schools.

IV. IMPLICATIONS FOR TEACHERS AND PRINCIPALS

Certain implications are suggested that may be of considerable interest to teachers and administrators:

(a) The findings that indicated strong preferences for sociable learning environments, coupled with the favourable achievement increments likely to be derived from from grouped instruction techniques, suggest that present trends in educational administration toward totally private and independent individualized instruction need to be both carefully interpreted and further researched. While it is not too likely that pupils in our present open area schools will completely isolate themselves from other pupils, it is still possible that systematically planned interaction periods with their peers may be omitted. Similarly, in traditional classrooms, it is possible that in day-to-day scheduling there may be, for many students, no definitely planned interaction sessions with fellow students. It should be noted that placing the same few pupils in the same group for an entire year may not be describable as a stimulating environment for children.

(b) The economies and efficiencies of allowing pupils to teach pupils need further investigation and promotion. This does not imply that professionally planned experiences are not necessary. Rather, it suggests that there are certain types of interaction situations that should be capitalized upon and which may yield savings in teacher time and energy without sacrificing student achievement.

(c) There are economies and efficiencies related to science materials that can be provided by the use of groups for instruction. This is especially true in terms of expendable materials such as chemicals. An individualized laboratory program in science might make it possible for one tuning fork to be used successively by thirty pupils --in lieu of thirty tuning forks--but the same thing cannot be done with an acid-litmus reaction. In such situations grouping might effect economies and it might enhance the learning situation at the same time. Pairs and other very small groups need to be compared to successively larger groups to obtain the optimum size that will produce the desired effect.

It might be emphasized that there is likely to be little difference in achievement on a day-to-day basis, regardless of whether groups are used or not. However, teachers should consider intraclass grouping as another dimension to instruction that may contribute to the goals of a democracy and to meeting the social needs of pupils. It might also be suggested that students should be enabled to participate in a variety of group experiences throughout the week, some of which would supply "primary" group experiences while others might encourage building of democratic and social skills.

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APPENDICES

APPENDIX A

CALCULATION OF THE SCIENCE MEASURE RELIABILITY USING THE KUDER-RICHARDSON AND HOYT METHOD

SUBJECTS	Items: ABCDEFGHIJKLMNOPQRS Test # 1	ABCDEFGHIJKLMNOPQR Test # 2	ABCDEFGHIJKLMNOPQRS Test # 3	T_c	T_c^2
1	/ . . . . / / / / / /	. . / / . . . . / / / / / . / / / /	. . . . / / / / / / / / / / / / / / /	23	529
2	. . . . / . . / .	. . . . / / / / / / . / / /	. . / / . / . . . . . / / / / . . / /	36	1296
3	. . . . / /	. . / . / . / . / / / / / / / / . /	. / / / / / / . / / / / / / . / / / /	26	676
4	. . . . / . . . . . / . . / .	. . . . / . / . . / . / . /	/ . / / / / / / . / . / / / / . . . /	35	1225
5	. . / / / . . . . / . . / .	. . / . . . . . / / . / / / / / . /	. . / / / / / . / / / / / / / / / / /	26	676
6	/ / / / / / / . . . / . / . / . . / .	. . / / . . / . / . / . / / / . . /	. . / / . / / . / / . / / / / / / / /	22	484
7	/ . / . . . . / / / / / . . / .	. / . . / . . / / / . . / / / . / /	. . / . . . . / / / / / / / / / / / /	25	625
8	. . . . / . . / . . / / / / /	. . . / . . . . / / / / / / / / / /	. . / . . / / . . / . . / / / / / / /	27	729
9	. . . . / / / . / . / / /	. / / . . . . / / . / . . / / . . /	/ . / . / / / / / / / / / / / . / / /	25	625
10	/ . . . . / . / / .	. / / . . . / . / / . . / /	. . / . / / . . . / . / . / / / / / /	34	1156
11	/ / . . . . / / / . / . . / .	/ . / / . . . . / / . . . / . . . /	. / / . . / . . . / . . / / / . / / /	32	1024
12	/ . / / / / . . / . . . . . / . . / /	. / / / . . . . / / . / . / / / . /	. . / . . . . . / / . . . . / / / / /	29	841
13	. . . . / . / / .	/ . / / . . . . / / . . . / . / . /	. . / . . / / . / / / . / . / / / / /	33	1089
14	/ . . . . / . . / .	. / / / . . . . / / . . . / / / / .	/ . / . . . . . / / . / / / / / / / /	32	1024
15	. . / / / . . . . . / / / / / / / / /	. . / / . . / . / / / / / / / / / /	. . / . . / / / / / / / / / / / / / /	16	256
16	/ . / . . . . / . . / /	. . . . . / . . / / . . / . . / . /	. . . . / / . . . . / . . / / / / / /	36	1296
17	/ . . . . / / .	. . / / . . . . / / . . . / . / / /	. . / . . / / . . / . . / / / / / / /	34	1156
18	/ . . . . / . / / .	. . / . / . . / / / . . . / / . . /	. . . / / . / / / / . . . / / / / / /	32	1024
19	. . . . / .	. . / . . . / . / / / / / / . / / /	. . / / / / . / / . / . / / / / / / /	31	961
20	/ . . . . / . . . . . . / / / /	. . / . . . . / / / / / / / / / / /	. . / / . / / / / / / / / / / / / / /	22	484
21	/ / . / . . . . . / . / . . / / / / /	. / / / / . . / / / . . . / / / / /	. . / . . . . . / / . / / / / / / / /	23	529
22	. . / . . . . / / / . / / / / /	. / / . . . . . / . . / / / / / / /	. . / . . . . . / / / / / / / / / / /	25	625
23	. . . . / . / . . . . / . / / .	. / / . . . . . / / . . . / / / / /	. . / . / / / . / / / / / / / / / / /	27	729
24	. . / . . . . / . . / .	. . . . / / . . . . / . . /	. . . . . / / / / . . . / / / / / / /	38	1444
25	/ . . . . / .	. . . . . . / / / / . / . / . / / /	. . / / . / / / / / / / / / / / / / /	29	841
26	. . . . / . . . . . / . . / .	. . / / . . . . / / / . . / / / . /	. . / . . / / . . / . / / / / / / / /	32	1024
27	/ . . . . / . / / .	. . / / / / / . . / . / / / . / / .	. . / . . / . . . / . / / / / / / / /	30	900
28	. . / . . . . . / . / . / / / . / / .	. / . . / . . / / / / . / / . / . /	. . . . . / / / / / / / / / / / / / /	24	576
29	/ . / . . . / . / / . . . . / . / / /	. . / / . . . . / / / / / / / / / /	. . / / . / . . / / . . / / / / / / /	23	529
30	. . . . / / / / / . . / /	. . / / / . / . / / / / / / . / / /	/ / . . . / . / . / . / . / / / / / /	24	576
T_s	15 27 [illegible] 24 10 13	28 21 3 13 [illegible] 23 7 16 13 13 12 7 13	26 27 [illegible] 20 20 13 13 10 17 [illegible] 4 2 4 0	851	24949
T_s^2	225 729 400 625 [illegible] 225 0 324	784 441 [illegible] 529 16 256 [illegible] 169 144 49 169 9	676 729 [illegible] 400 400 169 361 100 289 [illegible] 36 4 16 4 0	17881 (ST_s^2)	

$$\frac{SS_I}{N_I} = \frac{24949}{56} = 445.52$$

$$ST_c = 851$$

$$\frac{ST_c^2}{N_s N_I} = \frac{724201}{30 \times 56} = 431.072$$

$$ST_c - \frac{ST_c^2}{N_s N_I} = 419.93$$

$$\frac{ST_c^2}{N_I} - \frac{ST_c^2}{N_s N_I} = 14.45 \ \#$$

$$\frac{ST_s^2}{N_s} = \frac{17881}{30} = 596.03$$

$$\frac{ST_s^2}{N_s} - \frac{ST_c^2}{N_I} = 164.96 \ *$$

$$ST_c - \frac{ST_c^2}{N_s N_I} - (\#+*) = 240.52 @$$

$$\frac{\#}{N_s - 1} = .4983$$

$$\frac{@}{(N_s-1)(N_I-1)} = .1507$$

$$\frac{.4983 - .1507}{.4983} = \boxed{.70}$$

APPENDIX B

SCIENCE SCORES SUMMARIZED FOR EACH OF THE ANOVA CELLS

CELL CODE			N	OBSERVATIONS
1	1	1	30	23 06 23 35 38 26 27 22 33 22 25 25 20 26 21 33 32 31 41 24 30 23 25 27 24 26 23 23 19 33
1	1	2	35	26 29 29 18 31 24 28 30 29 20 17 34 26 28 19 18 14 16 16 22 36 22 17 27 17 26 34 23 12 30 18 17 23 17 17
1	1	3	24	27 34 22 28 18 10 15 17 18 15 12 20 09 23 21 20 32 18 18 18 18 19 15 13
1	2	1	33	26 18 15 22 23 21 19 08 25 16 18 29 20 18 15 21 19 11 28 20 26 26 23 20 32 25 30 25 18 21 21 17 24
1	2	2	23	17 20 19 24 16 18 21 22 07 19 29 14 25 21 10 26 10 11 16 28 17 31 28
1	2	3	29	18 19 29 31 26 20 11 12 26 15 04 27 10 13 21 20 11 12 26 26 12 18 21 19 09 05 12 14 27
2	1	1	21	23 16 23 14 20 25 20 14 13 18 12 18 34 21 01 20 14 03 16 10 14
2	1	2	31	07 08 16 12 22 19 19 21 11 18 08 12 16 15 20 14 15 16 25 18 19 06 23 11 21 17 10 13 17 06 27
2	1	3	30	12 20 26 12 23 16 20 15 11 13 11 13 17 23 11 06 17 18 14 19 13 22 09 22 11 13 08 16 20 19
2	2	1	27	17 21 07 16 21 08 19 13 25 03 07 16 21 23 26 18 15 08 09 23 22 26 06 19 19 17 06
2	2	2	28	14 18 10 21 18 27 11 27 21 30 25 16 09 30 15 11 13 10 08 22 20 15 23 08 09 16 07 24
2	2	3	34	06 18 14 15 19 14 18 23 07 16 21 03 29 08 36 17 23 23 02 02 09 08 18 23 20 10 06 15 20 10 16 10 06 11
($\overline{\text{MA}}$.$\overline{\text{Tr}}$.$\overline{\text{SEc}}$.)				

APPENDIX C

MEANS AND STATISTICAL PARAMETERS FOR ALL THE LEVELS OF THE SINGLE SCIENCE MEASURE ANOVA

Factors Levels	N	POOLED MEAN	UNPLD. MEAN	INDIVIDUAL SD	INDIVIDUAL $(SE)^2$	INDIVIDUAL SE	POOLED $(SE)^2$	POOLED SE
M.A.								
1	174	21.37	21.16	6.93	0.28	0.53	0.25	0.50
2	171	15.82	15.91	6.61	0.26	0.51	0.25	0.50
Treatment								
1	171	19.63	19.39	7.34	0.32	0.56	0.25	0.50
2	174	17.63	17.68	7.17	0.30	0.54	0.25	0.50
M.A.xTrt.								
1 1	89	23.10	22.84	6.92	0.54	0.73	0.48	0.69
1 2	85	19.56	19.49	6.51	0.50	0.71	0.50	0.71
2 1	82	15.87	15.94	5.79	0.41	0.64	0.52	0.72
2 2	89	15.79	15.87	7.33	0.60	0.78	0.48	0.69
Socio-Econ.								
1	111	20.41	20.00	7.57	0.52	0.72	0.39	0.62
2	117	18.97	18.82	7.01	0.42	0.65	0.37	0.60
3	117	16.58	16.79	6.92	0.41	0.64	0.37	0.60
M.A. x S. Ec.								
1 1	63	23.59	23.71	6.41	0.65	0.81	0.68	0.82
1 2	58	21.71	21.33	6.65	0.76	0.87	0.74	0.86
1 3	53	18.38	18.45	6.87	0.89	0.94	0.81	0.90
2 1	48	16.25	16.29	6.98	1.02	1.01	0.89	0.94
2 2	59	16.27	16.31	6.31	0.67	0.82	0.73	0.85
2 3	64	15.09	15.13	6.64	0.69	0.83	0.67	0.82
Trt. x S.Ec.								
1 1	51	22.25	21.41	8.31	1.35	1.16	0.84	0.92
1 2	66	19.58	19.35	7.09	0.76	0.87	0.65	0.81
1 3	54	17.22	17.42	5.80	0.62	0.79	0.79	0.89
2 1	60	18.85	18.59	6.55	0.72	0.85	0.71	0.84
2 2	51	18.18	18.30	6.89	0.93	0.97	0.84	0.92
2 3	63	16.03	16.16	7.75	0.95	0.98	0.68	0.82
M.A.xTrt.xS.Ec.								
1 1 1	30	26.20	26.20	6.62	1.46	1.21	1.43	1.19
1 1 2	35	23.14	23.14	6.40	1.17	1.08	1.22	1.11
1 1 3	24	19.17	19.17	6.23	1.62	1.27	1.78	1.34
1 2 1	33	21.21	21.21	5.25	0.84	0.91	1.30	1.14
1 2 2	23	19.52	19.52	6.57	1.88	1.37	1.86	1.36
1 2 3	29	17.72	17.72	7.41	1.89	1.38	1.48	1.21
2 1 1	21	16.62	16.62	7.24	2.49	1.58	2.04	1.43
2 1 2	31	15.55	15.55	5.55	1.00	1.00	1.38	1.18
2 1 3	30	15.67	15.67	5.00	0.83	0.91	1.43	1.19
2 2 1	27	15.96	15.96	6.91	1.77	1.33	1.59	1.26
2 2 2	28	17.07	17.07	7.07	1.79	1.34	1.53	1.24
2 2 3	34	14.59	14.59	7.86	1.82	1.35	1.26	1.12
TOTAL:	345	18.62	18.54	7.32	0.16	0.39	0.12	0.35

APPENDIX D

MEANS AND STATISTICAL PARAMETERS FOR ALL THE LEVELS OF THE INTERACTIONS AMONG THE THREE FACTORS OF THE SINGLE SCIENCE MEASURE ANOVA

FACTOR	LEVEL	N	SD	$\overline{SD}^2$	SE	MEAN
M.A. x Tr.	Hi, Grouped	89	6.92	47.89	0.73	22.84
	Hi, Control	85	6.51	42.38	0.71	19.49
	Lo, Grouped	82	5.71	32.60	0.64	15.94
	Lo, Control	89	7.33	53.73	0.78	15.87
M.A. x S. Ec.	Hi, High	63	6.41	41.09	0.81	23.71
	Hi, Middle	58	6.65	44.22	0.87	21.33
	Hi, Low	53	6.87	47.19	0.94	18.45
	Lo, High	48	6.98	48.72	1.01	16.29
	Lo, Middle	59	6.31	39.82	0.82	16.31
	Lo, Low	64	6.64	44.09	0.83	15.13
Tr. x S. Ec.	Group, High	51	8.31	69.06	1.16	21.41
	Group, Middle	66	7.09	50.27	0.87	19.35
	Group, Low	54	5.80	33.64	0.79	17.42
	Control, High	60	6.55	42.90	0.85	18.59
	Control, Middle	51	6.89	47.47	0.97	18.30
	Control, Lo	63	7.75	60.06	0.98	16.16
Total Sample		345	7.32	53.58	0.39	18.54

APPENDIX E

MEANS AND STATISTICAL PARAMETERS FOR EACH OF THE TWELVE CELLS OF THE SINGLE SCIENCE MEASURE ANOVA

SOURCE			N	SD	$\overline{SD}^2$	SE	MEAN
M.A.	Tr.	S. Ec.					
Hi	Grouped	High	30	6.62	43.82	1.21	26.20
Hi	Grouped	Middle	35	6.40	40.96	1.08	23.14
Hi	Grouped	Low	24	6.23	38.81	1.27	19.17
Hi	Control	High	33	5.25	27.56	0.91	21.21
Hi	Control	Middle	23	6.57	43.16	1.37	19.52
Hi	Control	Low	29	7.41	54.91	1.38	17.72
Lo	Grouped	High	21	7.24	52.42	1.58	16.62
Lo	Grouped	Middle	31	5.55	30.80	1.00	15.55
Lo	Grouped	Low	30	5.00	25.00	0.91	15.67
Lo	Control	High	27	6.91	47.75	1.33	15.96
Lo	Control	Middle	28	7.07	49.98	1.34	17.07
Lo	Control	Low	34	7.86	61.78	1.35	14.59
	Total Sample		345	7.32	53.58	0.39	18.54

APPENDIX F

A COMPARISON OF THE CELL MEANS OF THE ANOVA's OF SCORES CORRECTED FOR CHANCE AND THOSE NOT CORRECTED FOR CHANCE

Factor Levels			N	Pooled Means	Unpld. Means	Individual SD	Individual $(SE)^2$	Individual SE	Pooled $(SE)^2$	Pooled SE
M.A.xTr.xS.Ec.										
					CORRECTED FOR CHANCE					
1	1	1	30	26.20	26.20	6.62	1.46	1.21	1.43	1.19
1	1	2	35	23.14	23.14	6.40	1.17	1.08	1.22	1.11
1	1	3	24	19.17	19.17	6.23	1.62	1.27	1.78	1.34
1	2	1	33	21.21	21.21	5.25	0.84	0.91	1.30	1.14
1	2	2	23	19.52	19.52	6.47	1.88	1.37	1.86	1.36
1	2	3	29	17.72	17.72	7.41	1.89	1.38	1.48	1.21
2	1	1	21	16.62	16.62	7.24	2.49	1.58	2.04	1.43
2	1	2	31	15.55	15.55	5.55	1.00	1.00	1.38	1.18
2	1	3	30	15.67	15.67	5.00	0.83	0.91	1.43	1.19
2	2	1	27	15.96	15.96	6.91	1.77	1.33	1.59	1.26
2	2	2	28	17.07	17.07	7.07	1.79	1.34	1.53	1.24
2	2	3	34	14.59	14.59	7.86	1.82	1.35	1.26	1.12
TOTAL SAMPLE			345	18.62	18.54	7.32	0.16	0.39	0.12	0.35
					NOT CORRECTED FOR CHANCE					
1	1	1	30	30.60	30.60	5.74	1.10	1.05	1.09	1.05
1	1	2	35	28.11	28.11	5.57	0.89	0.94	0.94	0.97
1	1	3	24	24.21	24.21	5.77	1.39	1.18	1.37	1.17
1	2	1	33	25.82	25.82	4.93	0.74	0.86	0.99	1.00
1	2	2	23	24.17	24.17	6.27	1.71	1.31	1.43	1.19
1	2	3	29	23.17	23.17	6.50	1.46	1.21	1.13	1.06
2	1	1	21	21.86	21.86	5.26	1.32	1.15	1.56	1.25
2	1	2	31	21.52	21.52	4.73	0.72	0.85	1.06	1.03
2	1	3	30	21.53	21.53	4.50	0.68	0.82	1.09	1.05
2	2	1	27	21.48	21.48	6.08	1.37	1.17	1.21	1.10
2	2	2	28	22.75	22.75	5.98	1.28	1.13	1.17	1.08
2	2	3	34	20.62	20.62	6.92	1.41	1.19	0.96	0.98
TOTAL SAMPLE			345	23.92	23.82	6.38	0.12	0.34	0.10	0.31

APPENDIX G

ATTITUDE INVENTORY OR ENJOYMENT SCALE

INSTRUCTIONS: In your test booklet at the bottom of the answer page there are three number scales that look like this:

Act. 1)	1 2 3 4 5 6 7
Act. 2)	1 2 3 4 5 6 7
Act. 3)	1 2 3 4 5 6 7

These are for you to record your choices from those given below and which are the closest to agreeing with how you personally felt about each science activity. You may choose the same number three times or you may wish to choose three different numbers. (Activity # 1 -- Pendulum Lesson; Activity # 2 -- Balancing Lesson; Activity # 3 - - Computer lesson.)

1.	I really enjoyed the opportunity to work without any interference from others because I never enjoy working in groups.
2.	Working by myself during the lesson was the best part of the lesson since I never get much help from others anyway.
3.	If I had the choice I think I would try again to work alone during the science lessons.
4.	Either I did not enjoy the lesson or else I felt quite unconcerned about whether I worked by myself or with others.
5.	If I had the choice I think I would try again to work with a group during science lessons.
6.	Working with others was the part of the lesson that I liked best since I do not enjoy working by myself.
7.	I really enjoyed the opportunity to talk and discuss with others during the learning part of the lesson since I never enjoy working alone by myself.

APPENDIX H

OBJECTIVES AND ACHIEVEMENT CRITERIA FOR THE THREE SCIENCE LESSONS

Pendulum - Operations of exclusion - Objectives for this lesson involved discovery of the variable or variables which determine the period of a pendulum. This required that students eliminate the variables that were not involved, as well as confirm experimentally those that affected the period.

The determining variable was the length of the string or cord from the weight to the support (or the distance of the "bob" from its swinging point). Variables expected to be eliminated included: color of the string, thickness of the string, weight of the bob, size and thickness of the bob, length or speed of the starting push, and distance from some datum line from which the bob was allowed to swing. Twenty minutes of time was allowed in which to discover as many as possible of the variables to be excluded or included. Discovery was to be made with no teacher assistance other than the removal of mechanical problems that the instructor felt were beyond the competence of the students at that level.

The achievement measure was a nineteen item, multiple choice, objective post-test. Fifteen of the test items were pictorial, and all new vocabulary was introduced by the instructor either with the lesson's administration and instructions or at the time of verbally reviewing the post-test instructions. A blackboard illustration of a typical problem was always included. Appendix I is a copy of the activity instructions, and Appendix J is a copy of the post-test.

included: color of the string, thickness of the string, weight of the bob, size and thickness of the bob, length or speed of starting push, and distance from some datum line from which the bob was allowed to leave. Twenty minutes of time was allowed in which to discover as many as possible of the variables to be excluded or included. Discovery was to be made with no teacher assistance other than the removal of mechanical problems that the instructor felt were beyond the competence of the students at that level.

The achievement measure was a nineteen item, multiple-choice, objective post-test. Fifteen of the test items were pictorial, and all new vocabulary involved was introduced by the instructor either with the lesson's administration and instructions, or at the time of verbally reviewing the post-test instructions. A blackboard illustration of a typical problem was always included. Appendix I is a copy of the activity instructions. Appendix J is a copy of the post-test.

Test #1: Individual Item Criteria

A - eliminate same shape

B - eliminate same shape

C - eliminate same size

D - eliminate shape and size

E - eliminate size and shape

F - eliminate size and shape

G - eliminate size or weight

H - choose length

I - eliminate size, length?

J - eliminate size and shape

K - length is criteria, question pattern changed

L - eliminate string thickness, size and shape

M - length is criteria

N - string thickness, etc.

O - eliminate push, etc.

P - restatement, resummarize

Q - same as "P"

R - vocabulary, recall

S - summarizing, elimination

It will be noted that students who had eliminated all other variables would have little difficulty with the test since the right answer is always concerned with the length of the pendulum.

Balancing, law of moments, and operations of exclusion - The objectives for this lesson involved the discovery of the mathematical relationships of an equal arm balance with a single weight on each side, (i.e. WD = wd, where the distance is that measured from the centre) and then, if possible, the discovery of the additive relationship involved when weights are positioned at two or more positions on each side. (Law of "Moments".)

When this lesson was originally designed, the assumption was made that most grade six children would have had some introduction to levers in a quantitative sense, but this was not so. The lesson was, therefore, modified to include the discovery of the simple "moments" relationship and then, if possible, either by analogy, insight, or other, extrapolate to the additive case. Appendix A (item analysis, Test #2) illustrates quite graphically the simple-moments portion of the test and the additive-moments portion. Apparently 22/30 of the subjects were able to achieve with some degree of success on the more difficult "additive moments" section of the test. Appendix K illustrates the activity instructions and Appendix L illustrates the post-test for this section.

Test #2: Individual Item Criteria

A - simple intuitive equal-weight-distance balance

B - simple moments relationship, recall of example used as blackboard problem

C - simple analogy to "B", a simple moments relationship

D - simple moments relationship

E - a repeat of "B", not likely to use recall at this point, therefore a simple moments arithmetic problem

F - a second level problem, but of a simple intuitive equal-weight-distance type

G - the additive law of moments type

H - same as "G", larger numbers involved

I - unequal numbers of weights, additive moments type

J - another style of question same content as "I"

K - simple test of additive moments rule

Test #2: Individual Item Criteria (cont'd.)

L - more complex additive moments rule

M - same as "L"

N - same as "L", numbers of weights increased, but with very small-number arithmetic

O - flexibility and judgment

P - abstract transfer of simple moments rule

Q - applied transfer of simple moments rule

R - abstract transfer of the simple rule generalized

While the achievement of all criteria was not expected for all students, a sufficiently large range was provided for the many possibilities of non-directed discovery.

Classification and "Mini-Computer" - This lesson was based on the coding and classification exercise as suggested by Schneider and Schneider (1968, pp. 152-57, 608-11). The objectives involved: classification and coding of objects using a yes-no, fourteen-property, classification system; the use of logic and vocabulary skills related to similarities and differences; and the demonstration of this acquired background of concepts and skills by punch-coding and using data cards to answer a series of post-test discrimination and classification problems, mini-computer style. The nineteen questions were merely a test of the thoroughness and understanding of the classification system coded into the cards. Dexterity skills were also measured. (See Appendix M and Appendix N.)

Test #3: Individual Item Criteria

A - a very simple counting question to build confidence

B - a shift from counting to classification of code words

C - an instructional question as preparation for a two-stage sorting sequence

D - similar to C

E - one-stage classification, sorting

F - a two-stage classification, sorting

G to N - two-stage classification, sorting

P - a test of observation and judgment skills

O,Q,R,S - three-stage classification and sorting. (Achieving correct answers requires accurately made and properly coded cards

All questions were multiple-choice and either used very simple vocabulary or else used the new vocabulary of the lesson.

The "not-manufactured" coding item created a "double-negative" which had to be explained at the same time as the coding vocabulary. Words new to most grade six students or requiring a much more precise operational definition were: manufactured, transparent, cylindrical, spherical, and edible. The instructor demonstrated the preparation of one card. This ensured that the vocabulary of the coding key was explained by the same administrative procedures from class to class.

Since the three lessons had broad-spectrum achievement objectives, uniform administration could not be too specific or direct. It was intended, instead, to create a learning situation with a range of objectives.

APPENDIX I

-1-

ACTIVITY INSTRUCTIONS FOR PENDULUM LESSON

It isn't always easy to guess just what the variables are in an experimental system. Consider the system just demonstrated by the instructor. It consisted of a weight, a piece of cord, and a popsicle stick. What do you guess are the variables in this system?

OBJECT FOR TODAY: TO SEE IF YOU CAN DISCOVER AS MUCH AS YOU CAN ABOUT WHICH VARIABLE HAS THE MOST EFFECT UPON THE PERIOD (round-trip-time) OF A PENDULUM.
or stated in another way:
WHAT ARE THE VARIABLES IN THE SYSTEM THAT MAKE A DIFFERENCE IN HOW LONG IT TAKES A WEIGHT TO SWING BACK AND FORTH?

SUGGESTION: Counting the number of swings, to and fro, or the "round-trip-times" for a fixed period of time is the best way of comparing what is happening.

0 0 0

TIMING DEVICE: To aid your investigation, a timing signal has been prepared which "dings" every ten seconds. This will make it possible to watch and count swings without trying to watch a clock too.

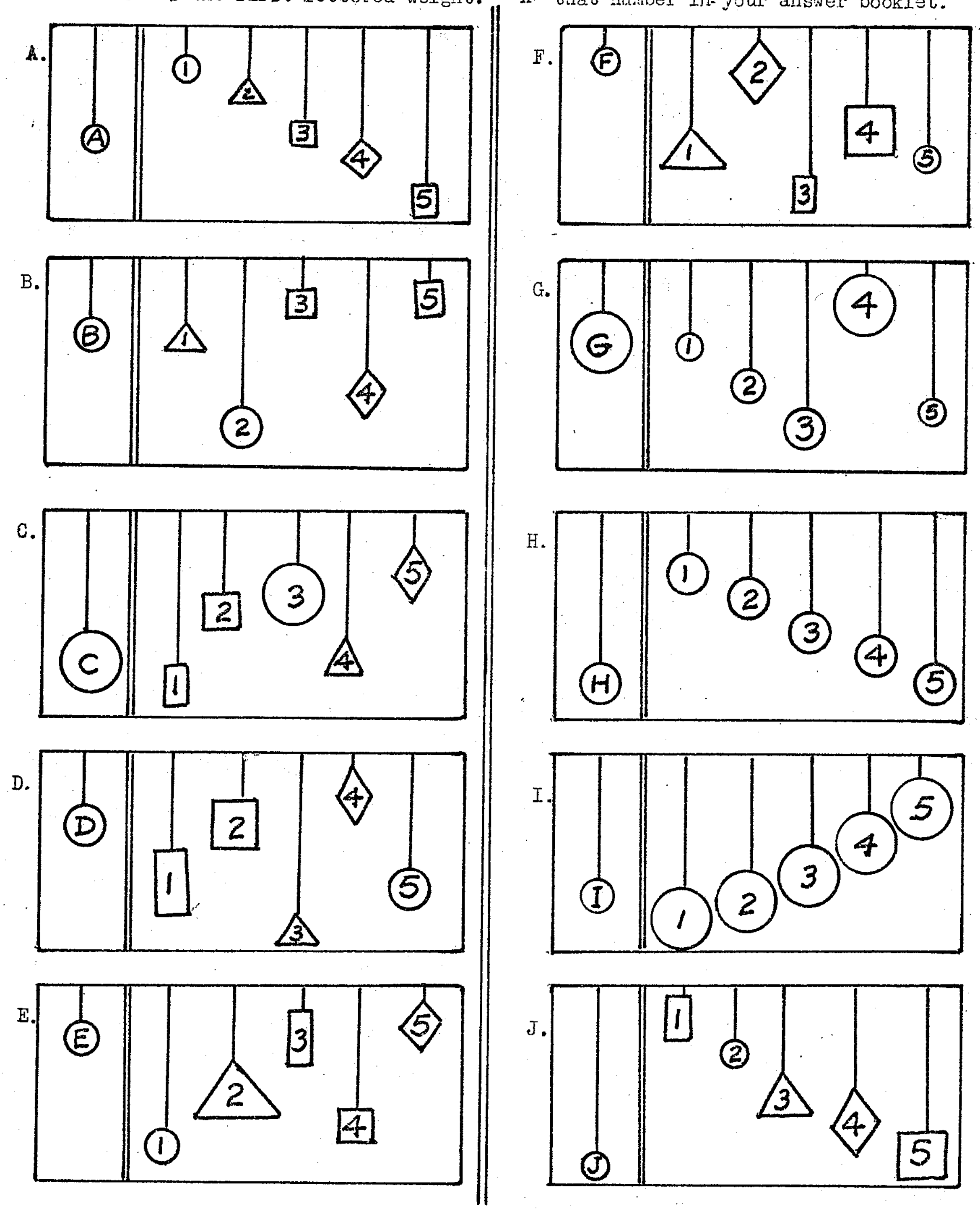
0 0 0

At the end of twenty minutes you will be asked to do a short test to find out how much you have discovered. Try and work as much as possible without help from the instructor.

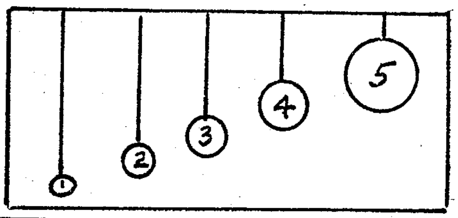
DO NOT WAIT FOR ANY FURTHER INSTRUCTIONS....PICK UP YOUR MATERIAL AND TAPE YOUR POPSICLE STICK SECURELY TO THE TOP OF YOUR DESK--ON THE SIDE OF THE DESK WHICH LEAVES LOTS OF ROOM FOR THE PENDULUM TO SWING. MAKE SURE THE TAPE IS PRESSED DOWN SECURELY AS SHOWN IN THE DIAGRAM. THE CORD WILL MOVE INTO THE GROOVE BETTER IF YOU DO IT WITH A SLIDING MOTION OF THE CORD.

APPENDIX J
-1-
PENDULUM POST TEST

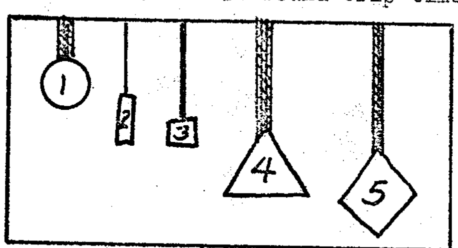
The following pictures show some weights hanging on strings. Each picture is a problem and has a letter to identify it in your answer book. Choose the NUMBERED weight which is MOST likely to swing with the NEAREST "round-trip-time" as the first lettered weight. "X" that number in your answer booklet.



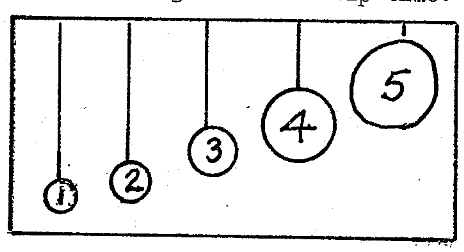
K. Which of the following will swing with the shortest round-trip-time?



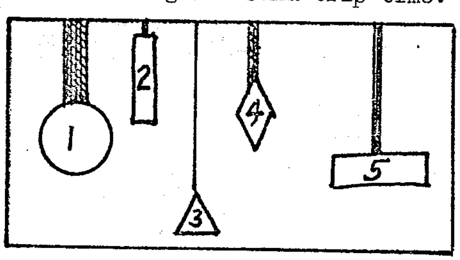
L. Which of the following will swing with the shortest round-trip-time?



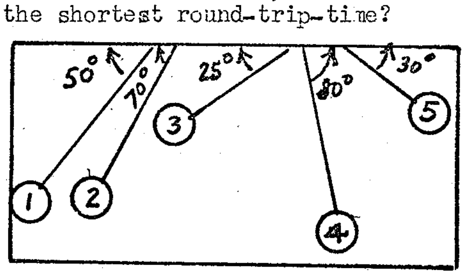
M. Which of the following will swing with the longest round-trip-time?



N. Which of the following will swing with the longest round-trip-time?



O. If the swinging weights are released with angles as shown, which will have the shortest round-trip-time?



P. Which will have the MOST effect upon changing the round-trip-time of a pendulum?
1. color of the string
2. thickness of the string
3. material of the string
4. attachment of the string
5. length of the string

Q. Which will have the most effect upon changing the round-trip-time of a pendulum?
1. color of the weight
2. size of the weight
3. material of the weight
4. attachment of the weight
5. none of these

R. Another name for "round-trip-swing" is:
1. amplitude
2. wave-length
3. vibration
4. frequency
5. none of these

S. Summarizing the law of the pendulum, we might say that the time of round-trip-swings is:

1. most related to weight of bob
2. most related to string length
3. most related to pushed distance
4. most related to string thickness
5. most related to air-resistance

<u>NOTE</u>: For the time you have left, you can use the space provided in the answer booklet to add any further information you discovered and which you did not find tested here.

APPENDIX K

ACTIVITY INSTRUCTIONS FOR LAW OF BALANCE

Discovering the law of the balance or of the lever is not as difficult as you might think. If you set up your balance carefully by following the instructions given by the teacher, and if you place your weights carefully and accurately in several positions as you test your predictions or hypotheses, you should be able to find out the mathematical rules for weights and their distance from the balance point. See how it is possible to place weights according to the rule and then to see the lever balance without any further adjustments.

OBJECT FOR TODAY: TO DISCOVER THE LAW OF THE BALANCE USING

(A) ONE WEIGHT ON EACH SIDE OF THE BALANCE POINT, BUT AT DIFFERENT DISTANCES FROM THE CENTRE;

(B) MORE THAN ONE WEIGHT ON EACH SIDE, AND WITH THE WEIGHTS AT DIFFERENT DISTANCES FROM THE CENTRE

or stated in another way:

CAN YOU FIND THE SIMPLE MATHEMATICAL RULE WHICH IS INVOLVED WHEN A LEVER IS AT A POSITION OF BALANCE AND WHEN THE WEIGHTS AND DISTANCES FROM THE BALANCE POINT ARE NOT ALWAYS EQUAL OR THE SAME ON BOTH SIDES.

SUGGESTIONS:

1. Balance your straight-edge very carefully. Check it for balance several times during your investigation. If it is giving you problems, check to make sure the elastic is quite tight.

2. Make sure you only use one type of washer. There are three types available. Mixing them will make it impossible to discover the rule for which you are testing.

3. Centre the washers on the "whole-number -inch marks" as shown by your teacher. (If you don't you will have to work with fractions in your mathematical rule.)

4. Your teacher will place a diagram on the blackboard. See if you can arrange your balance and washersas shown. This is a good test of your skill, of your balance, and it may also help you test your rule hypotheses.

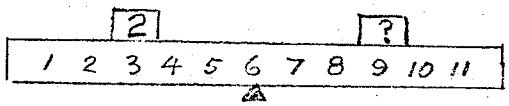
APPENDIX L

-1-

#2 POST TEST : LAW OF BALANCE

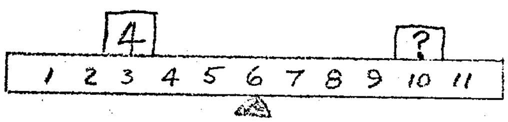
For the following questions: Assume that the ruler is balanced at the 6 inch mark when shown weights are involved. Weights are centered on the closest inch-mark as shown in the diagrams. A box like this: [3] means that there are three washers at that point. A box with a question mark like this: [?] means you are to select the BEST answer from those listed.

A.



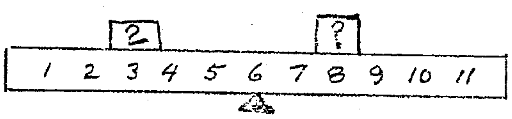
1. one washer
2. two washers
3. three washers
4. four washers
5. none of these

B.



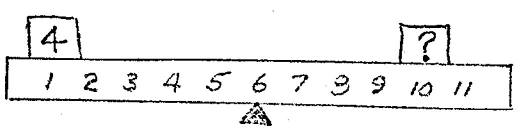
1. one washer
2. two washers
3. three washers
4. four washers
5. none of these

C.



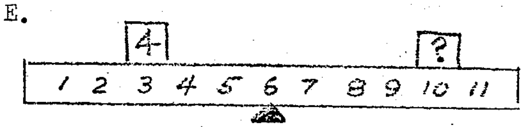
1. four washers
2. three washers
3. two washers
4. one washers
5. none of these

D.



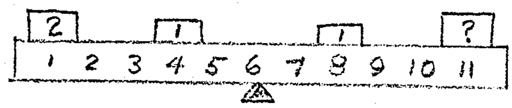
1. two washers
2. three washers
3. four washers
4. five washers
5. none of these

E.



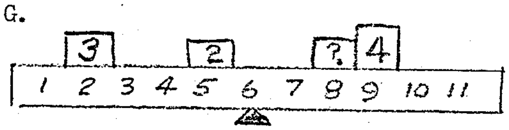
1. one washer
2. two washers
3. three washers
4. four washers
5. none of these

F.



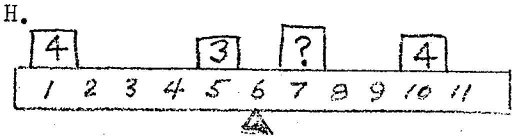
1. one washer
2. two washers
3. three washers
4. four washers
5. none of these

G.



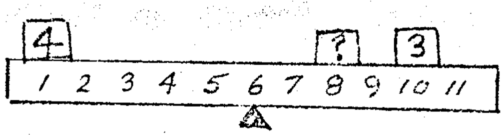
1. one washer
2. two washers
3. three washers
4. four washers
5. five washers

H.



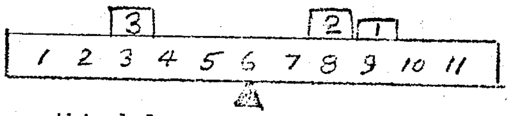
1. eight washers
2. seven washers
3. eleven washers
4. twelve washers
5. sixteen washers

I.



1. two washers
2. four washers
3. six washers
4. seven washers
5. none of these

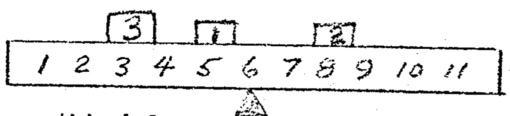
J. Choose the answer which best describes



this balance:

1. will go down on left
2. will go down on right
3. will balance
4. needs two washers at "5".
5. none of these

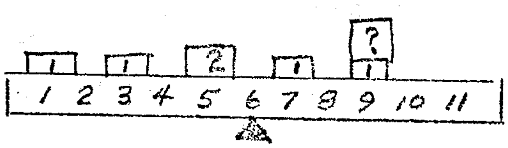
K. Choose the best answer which describes



this balance:

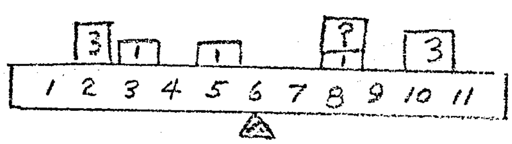
1. will go down on left
2. needs 1 washer at "8" to balance
3. will balance
4. needs 2 more washers at 10 to balance
5. none of these

L.



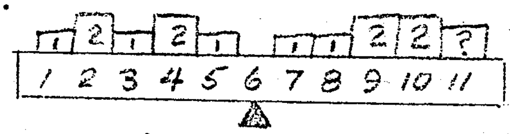
1. one washer
2. two washers
3. six washers
4. 8 washers
5. none of these

M.



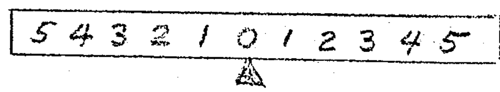
1. one washer
2. two washers
3. five washers
4. nine washers
5. none of these

N.



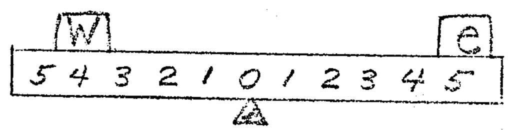
1. one washer
2. two washers
3. four washers
4. seven washers
5. none of these

O. This balance has the distance measured differently.



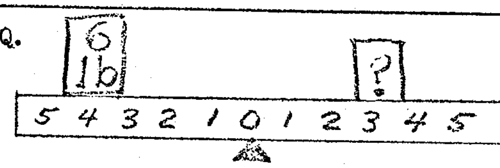
1. This is confusing
2. This is more difficult to use
3. This is opposite to what it should be.
4. This is better to work with
5. none of these.

P. For the weights balanced below:



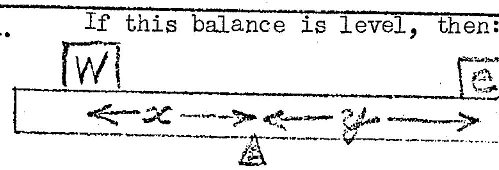
1. W = e
2. 5 x W = 4 x e
3. 4 x W = 5 x e
4. 4 + W = 5 + e
5. 4 + e = 5 + W

Q.



1. one washer
2. two pounds
3. four washers
4. eight pounds
5. twelve pounds

R. If this balance is level, then:



1. W = e
2. x = y
3. W + x = e + y
4. W x x = e x y
5. none of these

APPENDIX M

ACTIVITY INSTRUCTIONS
CLASSIFICATION

1. Your instructor will demonstrate the preparation of the code cards. Watch carefully how the "paths" are cut to the holes. Each "path" means the object has that property.

2. If an error is made, the "path" is closed again with "scotch tape.

3. You will need TEN cards, one for each of the ten objects hung at the front of the room.

4. Each card is coded with the properties of the object that are found ONLY ON THE CODING KEY LIST BELOW. (Other possibilities such as color, etc., will not be used today)

5. The CODING KEY is also used for the post-test, since the key is not printed on the code cards.

OBJECT FOR TODAY:

The object of today's lesson is to code on cards all properties of TEN objects according to a uniform code, and then to use these cards for answering questions of a CLASSIFICATION NATURE on the post-test.

CODING KEY:

A. Not manufactured	H. Cylindrical
B. Smooth	I. One hole
C. Transparent	J. Spherical
D. Would absorb water	K. Edible
E. Rounded	L. Metal
F. Shiny	M. Wood
G. Rectangular	N. Glass

You will have TWENTY minutes to carefully code the properties of each object on ONE CARD FOR EACH OBJECT.

After your cards are prepared, you will be using them, COMPUTER STYLE, to answer approximately 20 CLASSIFICATION AND SORTING QUESTIONS.

APPENDIX N -1-

Post Test # 3 - Classification

A. If you lift your ten cards using hole "C", how many cards fall out?
1. One
2. two
3. three
4. four
5. none of these

B. The type of objects you are looking for fall out when you lift and shake the bundle. How many cards of "edible" objects fall out if you lift your bundle at the "edible" hole "K"?
1. none
2. one
3. three
4. six
5. none of these

C. If you lift at hole "B" and then from those that fall out lift at hole "J", how many cards now fall?
1. four
2. three
3. two
4. one
5. none

D. How many objects are "Not manufactured? (i.e. How many cards fall out using hole "A"?
1. one
2. two
3. three
4. four
5. five

E. How many objects are cylindrical?
1. none
2. four
3. three
4. two
5. one

F. How many objects are spherical and also shiny?
1. none
2. one
3. two
4. four
5. none of these

G. How many objects are Rectangular and absorbent?
1. none
2. five
3. three
4. one
5. none of these

H. How many of the rectangular objects are "not manufactured?"
1. none
2. five
3. three
4. one
5. none of these

I. How many rounded objects have one hole?
1. none
2. five
3. three
4. one
5. none of these

J. How many shiny objects are made of glass and have one hole?
1. none
2. four
3. three
4. two
5. one

K. How many cylindrical objects are spherical?
1. none
2. one
3. two
4. three
5. none of these

L. How many objects are rounded and are also shiny?
1. none
2. three
3. five
4. six
5. seven

M. How many smooth objects are made of wood?
1. none
2. one
3. two
4. five
5. ten

(OVER)

APPENDIX N (Cont'd)

N. How many smooth objects are rounded? 1. none 2. ten 3. five 4. three 5. none of these	Q. How many glass things are also spherical and transparent? 1. none 2. one 3. two 4. three 5. four
O. How many smooth objects are spherical and are also shiny? 1. none 2. one 3. two 4. three 5. four	R. How many not-manufactured things have one hole, are rounded, and are cylindrical? 1. none 2. one 3. two 4. three 5. none of these
P. How many wooden things are water absorbent? 1. ten 2. seven 3. five 4. three 5. one	S. How many rounded objects are also spherical and also shiny? 1. none 2. five 3. three 4. two 5. one

APPENDIX O

-1-

MATERIALS DESCRIPTION
LESSONS 1, 2, 3.

LESSON # 1 - THE PENDULUM VARIABLES

Materials consisted of fish-line, washers for weights, a wire hook, a slotted popsicle stick, masking tape to attach the popsicle stick to the desk, a thicker piece of line, a one foot rule, and a piece of graph paper for data recording. A tape recorded chime was sounded every ten seconds allowing individuals to count pendulum swings without having to watch a clock at the same time. Figure 1* illustrates the method of setting up equipment.

LESSON # 2 - THE LAW OF THE BALANCE

Materials included "½-inch" washers for weights, a round pencil or wooden dowel, an elastic, two small wood blocks, a plastic one-foot rule, and a sheet of paper for data recording. Figure 2 shows the method of assembling the balance using these materials.

LESSON # 3 - CARD PUNCHING CLASSIFICATION

Ten miscellaneous objects were attached to a large piece of cardboard which was placed at the front of the classroom. See Figure 3. (This investigation used: a piece of bamboo, a Christmas tree glass ball, a potato, a rectangular shaped sponge, a plastic doughnut-shaped object, a plastic wedge, a piece of cement, a large glass alley,

* These figures refer to diagrams on page 115.

and a flat and a curled piece of birch bark.)

Each student was supplied with an instruction sheet containing a 14-point coding key (Appendix M), and with ten cards, lettered and punched around their perimeter (see inset, Figure 4) Each punched hole was labelled A, B, C, ...N, corresponding to the fourteen code-key items. A pair of scissors and a small dowel--shaped like a small knitting needle--completed the set. The instructor demonstrated the use of these materials by coding the most familiar object on the display board--the potato.

Each student had to punch one card for each object. The materials for this lesson were suggested by Schneider and Schneider (1968, pp. 152-57). It, in turn, is patterned after the 'Key Sort' techniques often advocated for certain types of office sorting and filing tasks.

Pendulum Lesson # 1

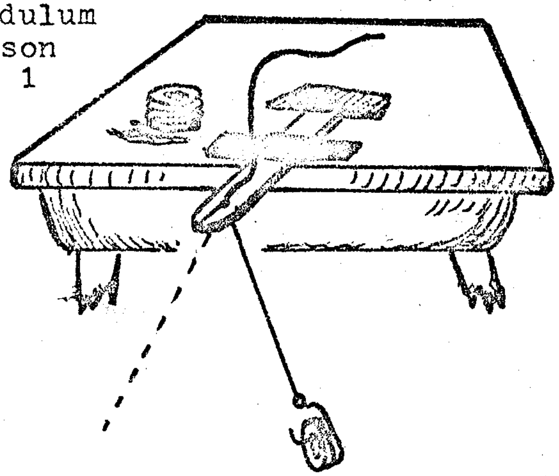


Figure 1

Balancing and Moments Lesson # 3

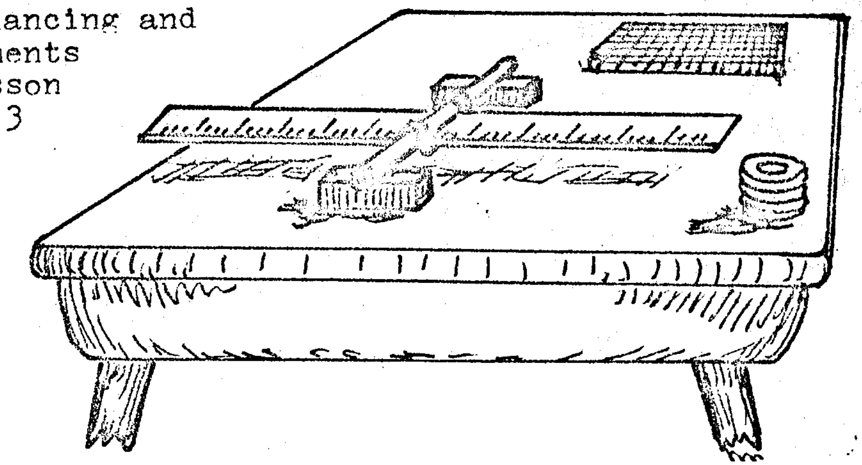


Figure 2

Classification Objects Lesson # 3

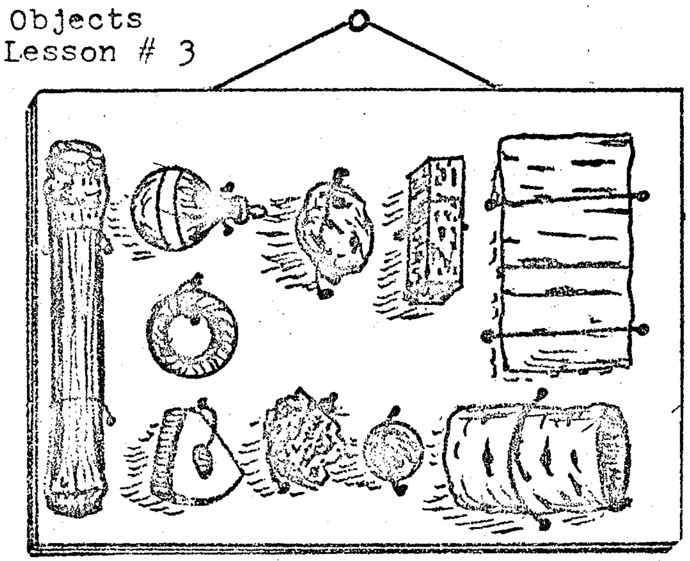


Figure 3

Card-Punching Equipment Lesson # 3

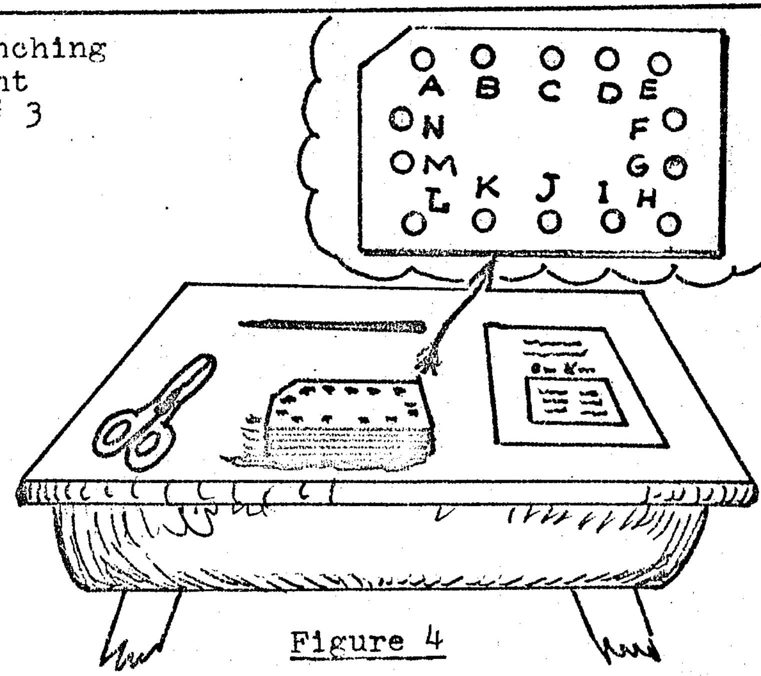


Figure 4

APPENDIX P
-1-
STUDENT ANSWER BOOKLET

Name ______________________________ Grade ____

School ____________________ Room # _____ Group # ____

Birthdate ______ (day) ______ (month) ______ (year)   Age ______ (years) ______ (months)

Occupation of Father ______________________________

INSTRUCTIONS: Each of the questions given on each test are answered like this example. The BEST answer is chosen from the five presented. In the answer book you go to the same question and "X" out the answer you have chosen:

QUESTION ON TEST:	ANSWER IN BOOKLET:
D. A clock is an instrument used for:	A. 1 2 3 4 5
1. Measuring distance	B. 1 2 3 4 5
2. Ringing doorbells	C. 1 2 3 4 5
3. Telling direction	D. 1 2 3 X 5
4. Telling time	E. 1 2 3 4 5
5. None of these	F. 1 2 3 4 5

If you make an error, then circle your wrong answer and make another "X" like this:

D. 1 X 3 (X) 5

Some questions may use pictures to ask questions or to give information. They are answered in exactly the same way. Choose the best answer and record it in this ANSWER BOOK, making sure you are using the corresponding question number.

A space is left at the bottom for writing in any other discoveries that you remember pertaining to the investigation.

(Do not write in this space - Instructor use only)

C.A. ______ (mo.)   M.A. ______ (mo.)   Reading Level ______ (Yr. Mo.)

APPENDIX P (CONT'D)

TEST # 1	TEST # 2	TEST # 3
A. 1 2 3 4 5	A. 1 2 3 4 5	A. 1 2 3 4 5
B. 1 2 3 4 5	B. 1 2 3 4 5	B. 1 2 3 4 5
C. 1 2 3 4 5	C. 1 2 3 4 5	C. 1 2 3 4 5
D. 1 2 3 4 5	D. 1 2 3 4 5	D. 1 2 3 4 5
E. 1 2 3 4 5	E. 1 2 3 4 5	E. 1 2 3 4 5
F. 1 2 3 4 5	F. 1 2 3 4 5	F. 1 2 3 4 5
G. 1 2 3 4 5	G. 1 2 3 4 5	G. 1 2 3 4 5
H. 1 2 3 4 5	H. 1 2 3 4 5	H. 1 2 3 4 5
I. 1 2 3 4 5	I. 1 2 3 4 5	I. 1 2 3 4 5
J. 1 2 3 4 5	J. 1 2 3 4 5	J. 1 2 3 4 5
K. 1 2 3 4 5	K. 1 2 3 4 5	K. 1 2 3 4 5
L. 1 2 3 4 5	L. 1 2 3 4 5	L. 1 2 3 4 5
M. 1 2 3 4 5	M. 1 2 3 4 5	M. 1 2 3 4 5
N. 1 2 3 4 5	N. 1 2 3 4 5	N. 1 2 3 4 5
O. 1 2 3 4 5	O. 1 2 3 4 5	O. 1 2 3 4 5
P. 1 2 3 4 5	P. 1 2 3 4 5	P. 1 2 3 4 5
Q. 1 2 3 4 5	Q. 1 2 3 4 5	Q. 1 2 3 4 5
R. 1 2 3 4 5	R. 1 2 3 4 5	R. 1 2 3 4 5
S. 1 2 3 4 5	S. 1 2 3 4 5	S. 1 2 3 4 5
T. 1 2 3 4 5	T. 1 2 3 4 5	T. 1 2 3 4 5
U. 1 2 3 4 5	U. 1 2 3 4 5	U. 1 2 3 4 5
V. 1 2 3 4 5	V. 1 2 3 4 5	V. 1 2 3 4 5
W. 1 2 3 4 5	W. 1 2 3 4 5	W. 1 2 3 4 5
X. 1 2 3 4 5	X. 1 2 3 4 5	X. 1 2 3 4 5
Y. 1 2 3 4 5	Y. 1 2 3 4 5	Y. 1 2 3 4 5
Z. 1 2 3 4 5	Z. 1 2 3 4 5	Z. 1 2 3 4 5
Other discoveries:	Other discoveries:	Other discoveries

DO NOT WRITE IN THIS SPACE UNTIL INSTRUCTED TO DO SO:

Act. 1)	1	2	3	4	5	6	7
Act. 2)	1	2	3	4	5	6	7
Act. 3)	1	2	3	4	5	6	7