AN EXAMINATION OF THE GRADE TWO STEM SCIENCE PROGRAM

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by

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ABSTRACT

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The purpose of this study was to critically examine the STEM Science Program in Grade Two so as to determine the extent to which the learning activities contained in the program provide a good match for Grade Two children.

A review of the literature revealed that a prevailing theory of child development is that of Jean Piaget. One science program in particular, the British Science 5/13 Program, used Piaget's stages as the basis for its selection of activities.

It was established that the Grade Two population, a majority of whom are 7 by December 31 and probably 7½ or older by the end of Grade Two, are either at the preoperational stage, or a transitional stage between preoperational and concrete operational thought, or the early concrete operational stage.

Activities from the Grade Two STEM Science Program were enumerated and found to be 270. Random sampling was then carried out to select 25 percent (68) of these activities for analysis. Each of these activities was examined in terms of what is required of the child, and this in turn, was analyzed in light of the capabilities of the pre-operational, early concrete operations child. In this manner it was possible to label an activity as being suitable or unsuitable for children at the Grade Two level.

The study revealed that 44.1 percent of the activities contained in the sample were more suitable for children operating at the later concrete operations and formal operations stages of development than for those at the pre-operational and early concrete operations stages and were, therefore, unsuitable for most Grade Two children. Based on these findings, recommendations were made for further research and for the provision of supplementary or alternate programs for Grade Two Science.

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CHAPTER I

INTRODUCTION

Statement of the Problem

In primary classrooms throughout Newfoundland and Labrador there has generally been one program used in the teaching of science. This is the STEM Science Program — "Space, Time, Energy, Matter" (Rockcastle, Salamon, Schmidt, McKnight, 1977). Nevertheless, some schools do have resources other than STEM, which have been used to supplement their science program.

Since STEM has been and still is the basis for science programs in the primary schools of the province, it is important that this basis be an exceptionally good one that meets the needs of the children for whom it is intended. It becomes necessary then to examine this program in the light of some theory of child development. In examining STEM, one must ask if the program is suitable in terms of the development and abilities of the primary school child. The question arises "What should be the theoretical basis upon which a science program should be based?"

The theory upon which the selection of a program is based should be a sound one which will take into consideration the general development of children and the specific capabilities which children possess at the different stages along the continuum of their development.

Navarra (1955), in "The Development of Scientific Concepts in a Young Child", indicated that there was a concern for the development of children. The foundations of modern child psychology, he notes, have been attributed to Wilhelm Preyer. Preyer was aware of the individual differences in children but felt that the differences were much more of time and degree than of the order in which steps are taken. He contends that the specific steps that are taken are the same in all individuals.

A similar concern for the stages of development and individual differences is inherent in Dewey's basic themes: "begin where the child is", "recognize individual differences", and "seek growth within the individual" (Seefeldt, 1976, p. 132).

In the past two decades there has been much emphasis on applying Piaget's theory of child development in science curriculum development. This has been reflected in texts prepared for children. In the British Schools Council Guide to Science 5/13 Program (1972) reference is made to the fact that Piaget's stages of development are adhered to. Ennever et. al. state in one booklet of this series, With Objectives in Mind, "Since we follow quite closely Piaget's ideas about development, our stages 1, 2 and 3 have similar properties to Piaget's stages ..." (p. 10). Another prominent science program which is widely used in primary schools and is based on aspects of Piaget's developmental theory is SCIS (Science Curriculum Improvement Study).

Piaget has had extensive influence on educators' views of how young children learn science (Seefeldt, 1976, p. 135). The potential application of Piaget's theory can be seen in many aspects of science learning and teaching because Piaget explicitly outlines the characteristics of children at the various levels of development and evidence has been accumulated in support of those stages. Thus, Berger (1974) can write, "Jean Piaget is generally considered the foremost child psychologist of this century" (p. 77).

Psychologists and educators alike (e.g., Hunt, 1961: Flavell, 1963; Almy, 1966) have found that Piaget's theory, which is increasingly supported by empirical evidence, may serve as a conceptual framework for assessing a child's mental development, in general, and his ability to comprehend and utilize abstract concepts, in particular (Goldschmid and Bentler, 1968, p. 4).

According to Piagetian theory, most primary children are in a very early stage of development, namely pre-operational. In later primary some children are also into the concrete operational stage. Beard (1969) refers to the stages of development of the primary-aged child when she writes, "Period IIA extends from about eighteen months to about seven years, and is a pre-operational period. It is again subdivided into two stages; the first extending until about four years they call the pre-conceptual stage; the second is the intuitive stage. Period IIB extends roughly from seven years to adolescence and is the period of concrete operations" (p. 15).

Piaget believes that children at these stages will be capable of performing certain cognitive tasks but not others. This is particularly true of conceptual development in science. A good science program should be such that it can be mastered with interest by the average child in these stages. There must be the right mixture of the familiar and the novel, the right match to the particular stage of learning of the child.

According to Harlen (1977) "The notion of 'matching' is central to our ideas about helping children to make progress" (p. 7). "The keynote to matching is... finding the right challenge for a child, the size of step that he can take by using but also extending existing ideas. There is as much a mismatch if this step is too small, leading to boredom, as there is if it is too large, leading to failure (Harlen in Richards, 1980, p. 60).

Strauss (1972) contends that if the learner has the appropriate internal capabilities, one can create external conditions which would facilitate positive vertical transfer. Furthermore, he points out that "To create such a situation we would presumably first analyze the tasks within each curriculum unit in such a way that we would know which level of reasoning (i.e., which mental organization) is required for a successful solution of each task. We would then test to see if a child had acquired this level of reasoning. If a match exists, the probability of task solution is greater than if the task's solution requires a higher level of operation than the child possesses" (p. 100).

In being a good match for a child, according to the Piagetian model, a science program should involve the child as much as possible from an interactionist point of view. It should comprise activities that will not be too difficult nor too simple, but rather, will help the child and add to his development by 'stretching' him.

Given the widespread acceptance of the Piagetian model and the fact that there is only one science program designated for primary schools in Newfoundland, it seemed worthwhile to examine this program with the aim of ascertaining to what extent the particular activities outlined in the texts provide a developmental match with the level of the children for whom it was intended.

As far as the writer's research could determine, STEM science has not previously been examined in this context.

Purpose of the Study

The main purpose of this study was to critically examine the STEM Science Program in Grade Two so as to determine to what extent the learning activities provided in the program constitute a match between activities and the developmental level of the learner, as suggested by Piagetian theory.

Such an examination would help to determine the suitability of the present program. In terms of this examination, suggestions were to be made for a supplementary or a modified program.

Need for the Study

When the STEM Science Program was adopted for the Newfoundland schools, it was not accepted on the basis of whether or not there was a match between the activities in STEM Science and the developmental stages of the child. It appeared that the program was recommended by the Provincial Science Curriculum Committee with specific guidelines for program selection. The adoption of the program, by the director for the province, was not based solely on the developmental theory of Jean Piaget.

Since in Newfoundland schools it is policy to have a common science program, that program should be comprised of activities which would be a good match for the target population. A good science program should be such that it can be mastered with interest by the average child.

Harlen (1980) contends that if the material is too familiar or the learning skills too easy, children will become inattentive and bored.

If too great maturity is demanded of them, they fall back on half remembered formulae and become concerned only to give the reply the teacher desires.

There is really no substitute in a child's schooling for the appropriate learning experiences. They are extremely important if children are to grow intellectually and benefit from instruction."

Limitations

1. Only activities from the printed page were examined in terms of suitability as opposed to observing children carrying out these activities. This may or may not have reflected classroom practice.
2. A random sample of activities from the Grade Two STEM Science Program was examined and this may or may not have been representative of the total program, despite appropriate sampling procedures.

CHAPTER II

REVIEW OF RELEVANT LITERATURE

Introduction

Given the vast amount of literature that has been written by Piaget and by others about his developmental theory, any literature review can be at best a representative selection.

According to Pulaski (1980), Piaget has been publishing prolifically ever since he was eleven, and it has become a monumental task to keep up with his productions. He is the author of at least fifty books (Pulaski, 1980, p. xiv). Flavell (1968) says that Piaget had written more than 150 journal articles in a period of more than 40 years. Consequently, this chapter will deal only with his recurring themes and those aspects of his writings which are most relevant and which relate to this study.

In this section those terms which Piaget frequently uses will be defined; his conception of a child's development of knowledge will be reviewed; the different stages of development which Piaget described will be looked at; and there will be an examination of some of the research related to the topic.

Definitions of Terms Frequently Used by Piaget

ABSTRACT THINKING — Thinking that is removed or disengaged from the concrete; characterized by the ability to form pure abstractions and to reason on a purely verbal level (Gorman, 1972, p. iii).

ACCOMMODATION — The process of reaching out and adjusting to new and changing conditions in the environment, so that pre-existing patterns of behavior are modified to cope with new information or feedback from external situations (Pulaski, 1980, p. 231).

ADAPTATION — A biological mode of functioning that characterizes all forms and levels of life. It consists of the dual processes of assimilation and accommodation, which go on continuously (Pulaski, 1980, p. 231).

ASSIMILATION — The process of taking in from the environment all forms of stimulation and information, which are then organized and integrated into the organism's existing forms or structures, thus creating new structures (Pulaski, 1980, p. 231).

CONCRETE OPERATIONS — Operations concerned with concrete, existing objects, and include ordering, serial arrangements, and classification, as well as mathematical processes (Pulaski, 1980, p. 234).

CONSERVATION — Understanding that objects or quantities remain constant in quantity despite changes in their appearance (e.g., one cup of milk is the same amount whether poured into a tall, thin glass or a wide, shallow bowl (Pulaski, 1980, p. 232).

CONTENT — The behavior that informs us that functioning has occurred (Flavell, 1968, p. 18).

DECENTRATION — The secondary and continuing aspect of perceptual activity, by means of which errors or distortions of perceptions are corrected. Perception focuses first upon the most compelling aspect of a stimulus to the exclusion of others; decentration, or focusing on secondary aspects and incorporating them into the total percept, leads to modified and more accurate perception (Pulaski, 1980, p. 232).

EQUILIBRATION — The dynamic, continuously self-regulating process of balancing the changes brought about by constant assimilation and accommodation in order to arrive at a "steady state" or equilibrium. It is the organizing factor underlying all biological and intellectual development (Pulaski, 1980, p. 233).

FORMAL THOUGHT — Use of logical propositions and hypothetical reasoning. It is typically based on theoretical constructs rather than concrete experience (Pulaski, 1980, p. 234).

FUNCTION — The intellect's endeavour to relate the old and the new meaningfully (Flavell, 1968, p. 18).

INDUCTION — The type of reasoning in which a person derives a generalization from particular instances or experiences (Gorman, 1972, p. 113).

INTUITIVE REASONING — Characteristic of the preoperational child between four and seven. It is based on immediate perception but through trial and error may lead to correct conclusions (Pulaski, 1980, p. 234).

OPERATIONS — The interiorized activities of the mind, as opposed to the sensori-motor or physical activities of the body. Characterized by logical thought processes that are organized, structured, reversible, and can be generalized (Pulaski, 1980, p. 234).

REVERSIBILITY — A characteristic of logical operations that permits the mind to reverse its activity and go backward in thought in order to coordinate previously observed phenomena with present circumstances (e.g., if 2 and 2 make 4, then 4 less 2 leaves 2 once more) (Pulaski, 1980, p. 235).

SCHEMATA — Cognitive structures which refer to a class of similar action sequences that are strong, bounded totalities in which the elements of behavior are tightly interrelated (Flavell, 1968, p. 18).

SCHEMA — An ensemble of sensori-motor elements mutually dependent or unable to function without each other (Piaget, 1952, p. 244).

SENSORI-MOTOR — Knowledge based on information received through physical exploration and sensory stimulation; also to the earliest developmental period (Pulaski,

	1980, p. 236). (sometimes spelled as sensory-motor)
STAGES	Levels of development characterized by successively differentiated, more complex, and more highly integrated patterns of thought or behavior. Usually characteristic of certain chronological age ranges (Pulaski, 1980, p. 236).
STRUCTURE	An ordered, interrelated system of knowledge or operations (Gorman, 1972, p. 114).
SYMBOLIC REPRESENTATION	The use of symbols to represent external reality (Pulaski, 1980, p. 236).

<u>The Developmental Psychology of Piaget</u>

Piaget considers that certain processes underlie all learning, whether in simple organisms or in human beings. The two essential processes are on the one hand, adaptation to the environment and, on the other, organization of experience by means of action, memory, perceptions, or other kinds of mental activities (Beard, 1969, p. 2).

According to Renner and Stafford (1979), Piaget refers to organizations and adaptation along with assimilation and accommodation as the functional invariants of intelligence. Thus regardless of the age of the learner the process remains the same. It will always begin with assimilation and lead to organization and adaptation.

Although mental structures are also part of Piaget's model of intelligence, they are not invariant, they are constantly changing. It is possible that these changes begin the instant we are born and continue throughout our whole lives. Whenever a child is asked to learn something, he is really being asked to transform the inputs from his environment into his own mental structures.

Children must have maximum opportunities to assimilate their environment in order to develop increasingly complex mental structures and content. Piaget's work on concept formation indicates that in order for a concept to be comprehended a mental structure must always be present (Raven and Calvey, 1977).

Piaget (1964) describes four factors which, he believes, explain the development from one structure to another:

> 1. maturation which is a continuation of embryogenesis,
> 2. the role of experience or the effects of the physical environment on the structure of intelligence,
> 3. social transmission in the broad sense (linguistic transmission, education, and so on), and,
> 4. equilibration
>
> (pp. 176-186).

The fourth factor, equilibration, is a fundamental one in terms of matching. It can mean the coordination of the other three factors and to achieve equilibration it is not sufficient to tell a child why. A teacher would do better to create situations where structures can be discovered and the child can correct his own schemas.

Through progressive assimilations and accommodations, equilibration proceeds throughout the child's development and equilibrium is achieved at increasingly higher levels.

Shulman (1970) suggests that Piaget sees the child as a developing organism passing through biologically determined cognitive stages.

According to Maier (1965), Piaget implies two different assumptions which explain this evolution:

> 1. The organization and interrelationships of objects, space, causality, and time presume *a priori* the existence of definite patterns of intellectual development
> 2. The intellect organizes its own structure by virtue of its experience with objects, space, causality, and time, and the interrelationship of these environmental realities (p. 94).

Piaget argues that at each stage children do not copy what they encounter but actively construct reality out of their experiences with the environment. The realities constructed by children are, in a sense, a series of progressive approximations to adult reality ... and prior to adolescence, children lack the mental abilities to think, reason, judge, and make decisions in the way that adults do (Elkind, 1981, p. 97).

Piaget's theory of stages of human cognitive development enables us to gain a better understanding of what we can expect from children. It helps us become aware of how they perceive the world around them at different ages.

As Good (1977) writes, "Stages have been developed as an artifical means to communicate some very complex findings on children's thinking" (p. 139).

Piaget's four main stages of cognitive development are generally described:

1. Sensori-Motor Period (First two years)
2. Pre-operational Period (Two to seven years)

3. Period of Concrete Operations (Seven to twelve years)
4. Period of Formal Operations (Twelve years to adulthood).

It is Piaget's belief that the order of these stages of development is constant but the age at which a stage is realized cannot be absolutely fixed, for it is relative to the environment which may encourage, impede or even prevent its appearance (Beard, 1969).

Nadelman (1982) concurs with Beard in saying that the norms in a Piagetian description are merely rough guidelines for when things usually happen, for the theory makes no claim that abilities emerge at specific ages. Research reveals that there is wide variability in the speed with which children develop.

According to Good (1977), some children might develop a particular cognitive ability before the typical age range but the order of this development seems to be invariant, at least in the general sense. He contends that there seems to be a logical or preferred sequence in the development toward logical or formal operational thinking. This development consists of four distinct stages.

The first and fourth stages of development (sensori-motor and the formal operational, respectively), are not as significant for this study as are the second and third (pre-operational and concrete operational) stages because it is reasonable to assume that most children at the grade two level would be operating within the limits of the second and third stages.

The latest statistics which could be obtained from the Department of Education regarding the percentage of grade two students who would be seven years old in the province was obtained from the Statistical Supplement to the Annual Report of the Department of Education for the school year ending June 30, 1973. For that year 61.7% of the total number of grade two students in the province were seven years old. However, upon checking with a number of schools in the St. John's area it was discovered that the percentage of grade two students who are seven years old is much higher - ranging from 75% in inner-city schools to 96% in some other schools.

Since seven-year-olds are generally in the preoperational and/or concrete operations stages, these two stages will be described in greater detail. The sensori-motor and the formal operations stages will be looked at, however, so that in cases where the activities in the Grade Two STEM Science book appear to be more suitable for these levels, they can be identified as such.

The first stage is referred to as the sensori-motor stage and is generally considered to last for the first two years of life. According to Pulaski (1980), this period can be subdivided into six sub-stages. During sub-stage 1 the child has no awareness of self as such or of the distinction between self and the outer world. Then comes the second sub-stage where the child begins to define the limits of his own body through accidental discoveries. It is during sub-stage three that the child learns to adapt familiar schemes to new situations and his interest becomes focused more on the world around him. Intentional behavior begins to emerge during sub-stage four.

Throughout sub-stage five the child is able to follow visible displacements of an object being hidden. The final sub-stage of the sensori-motor period marks the transition from sensori-motor to representational activity. The child shows purpose, intention, and the beginnings of deductive reasoning, along with a primitive understanding of space, time, and causality (Pulaski, 1980, pp. 214-215).

The pre-operational stage is the second of Piaget's four stages of development and is most often observed in children from two to seven years of age (Pulaski, 1980).

According to Piaget (1964) it is during this period that the child acquires the beginnings of language, of symbolic function, and therefore of thought or representaion.

Pulaski (1980) contends that while the child manages quite realistically in the physical world, his thinking is still egocentric and dominated by a sense of magic omnipotence. He assumes that all natural objects are alive and have feelings and intention because he does. Prelogical reasoning appears during this stage of development, and it is based on perceptual appearances (e.g., half a cup of milk which fills a small glass is more than half a cup which doesn't fill a large glass). Trial and error may lead to an intuitive discovery of correct relationships, but the child is unable to take into account more than one attribute at a time (e.g., blue beads cannot at the same time be wooden beads). Language is used in an egocentric way, reflecting the child's limited experience (Pulaski, 1980, p. 216).

According to Lavatelli (1970), the pre-operational stage can be described as having these characteristics:

1. The child is perceptually oriented; he makes judgements in terms of how things look to him.

2. The child centers on one variable only, usually the variable that stands out visually. He lacks the ability to coordinate variables.
3. The child has difficulty in realizing that an object can possess more than one property and thus can belong to several classes at the same time.

(pp. 29-33)

Flavell (1963) favors thinking of preoperational thought as thought which bears the impress of its sensori-motor origins, that is, as saturated with sensori-motor adherences. His thinking is based on the fact that the child at this stage is extremely concrete, his thinking is slow and static, and he is relatively unsocialized and unconcerned with proof or logical justification. In general, the child is unaware of the effect of his communications on others.

According to Lovell (1966), there is a great increase in the power of reversibility of thinking from seven years of age onwards. Children cannot learn from mere observations. From about seven years of age the child increasingly develops new and more complicated schemas. He becomes aware of the sequences of action in his mind, and he can see the part played by himself in ordering his experience. So it becomes possible for the child to build the concepts of class, relation, number, weight, time etc. However, it is only concepts that can be derived from contact with first-hand reality that can be elaborated by him. For example, the average seven-year-old does not appear to understand that the amount or quantity of matter stays the same regardless of any changes in shape or position. This concept of conservation of substance is an important one, for the mind can only deal effectively with a lump of plasticene, a glass of water, or a collection of shells, if they remain permanent in amount and independent of the rearrangement of their individual parts.

Space can still be tied to motor acts for children at seven years of age. It can be a concrete space and has not been sufficiently internalized for it to be subjected to mental operations. It remains, therefore, inflexible in the mind (Lovell, 1966).

Some concepts, according to Lovell (1966), are attained by the time a child is seven years old because of the mere fact of everyday experiences. Conventional time words used in the calendar and the organization of the week are well understood by the average seven-year-old and some seven-year-olds can understand horizontal and vertical because of their experiences with horizontal and vertical in everyday life.

Both the pre-operational stage and the stage of concrete operations utilize representational thought. However, Flavell (1969) recognizes the difference between these two stages when he describes the concrete operational child as one who behaves in a variety of tasks as though an integrated assimilatory organization were functioning in equilibrium or in balance with a discriminative, accommodatory mechanism.

According to Pulaski (1980) there is a very gradual transition into the period of concrete operations. The child in this stage can think logically about things he has experienced and manipulate them symbolically, as in arithmetic operations. He achieves a series of conservations. For example, he recognizes that a cup of milk is the

5. Tautology: an operation related to logical classifications. Here repetitions of a proposition, or relation leaves them unchanged.

Before a child has reached the concrete operations stage, however, he is unable to accomplish these operations. Flavell (1968) refers to some very significant limitations of the concrete operations stage:

> 1. Concrete operations are concrete, relatively speaking; their structuring and organizing activity is oriented towards concrete things and events in the immediate present. There is some movement towards the nonpresent but it is of limited scope and consists mostly of simple generalizations of existing structures to new content. What the child does not do is delineate all possible eventualities at the outset and then try to discover which of these possibilities really do occur in the present data.
> 2. The concrete-operational child has to vanquish the various physical properties of objects and events because his cognitive instruments are insufficiently "formal", insufficiently detached and dissociated from the subject matter they bear upon, to permit a content-free, once-for-all structuring.
> 3. The various concrete-operational systems (e.g., the logical groupings) do not interlock to form a simple, integrated system, a system by which the child can readily pass from one sub-structure to another in the course of a single problem. His various cognitive structures fail to combine into the unified whole necessary to manage certain complex tasks.
>
> (pp. 203-204)

The liberation from a distorting accommodation to immediate reality in the transition from pre-operations to concrete operations, moves another step in adolescence with the reversal in role between the real and the possible.

Flavell (1968) contends that there exists a basic reorientation towards cognitive problems at this stage. The adolescent same amount, whether seen in a tall, narrow glass or a short, wide one. An extremely important development is that he is now able to think backwards and forwards in time; that is, he has acquired reversibility of thought.

Copeland (1974) writes that the concrete operations stage marks the beginning of logico-mathematical thought and the child is "operational" in his thinking. At this stage the logical thought is based in part on the physical manipulation of objects. The child obtains ideas from actions on such concrete objects as water and clay.

Piaget (1964) indicates that many of the operations at this level are mathematical in nature. These operations include, according to Piaget (1964), those of classification, ordering, the construction of the idea of number, spatial and temporal operations, and all the fundamental operations of elementary logic of classes and relations of elementary mathematics, of elementary geometry and even of elementary physics (p. 3).

Hunt and Sullivan (1974) outline five specific operations of the concrete operations stage as:

1. Combinativity: an operation in which two classes may be combined into one comprehensive class that embraces them both.
2. Reversibility: every logical or mathematical operation is reversible in that there is an opposite operation that cancels it (for example, 3 plus 4 equals 7 can be reversed to 7 minus 4 equals 3).
3. Associativity: an operation combining several classes without regard to grouping (for example, (a plus b) plus c equals a plus (b plus c).).
4. Identity: an operation that can be nullified by combining it with its opposite (for example, +A -A equals 0).

now has the potential to imagine all that might be there - both the very obvious and the very subtle, in what Piaget (1964) refers to as the formal or hypothetico-deductive stage.

In describing formal thought, Flavell (1968) gives the following implied characteristics of that stage of development:

> 1. A cognitive strategy which tries to determine reality within the context of possibility is fundamentally hypothetico-deductive in character. The adolescent moves boldly through the realm of the hypothetical. His basic orientation towards the real and the possible leads him naturally and easily into reasoning of the general form.
> 2. Formal thinking is above all propositional thinking. The important entities which the adolescent manipulates in his reasoning are no longer the raw reality data themselves but assertions or statements - propositions - which "contain" these data. The adolescent takes the results of concrete operations, casts them in the form of propositions, and then proceeds to operate further upon them.
> 3. The adolescent systematically isolates all the individual variables plus all possible combinations of these variables. He subjects the variables to a combinatorial analysis, a method which guarantees that the possible will be exhaustively inventoried.
>
> (pp. 205-206)

Any propositions made by a child in the formal operations stage become part of the child's cognitive structure. This particular structure is based on the child's past experience. From this the child can make hypotheses that do not correspond to any particular experience.

According to Phillips (1969) the adolescent (unlike the child in the concrete operations stage) begins with the possible and then checks various possibilities against memorial representations of past experiences, and eventually against sensory feedback from the concrete manipulations that are suggested by his hypotheses (p. 103).

A major step forward in the stage of formal operations is made when the child can supplement the reversible operations of negation by that of reciprocity which entails the neutralization of a factor rather than its negation (i.e., holding its effect constant in some way while a second factor is being varied), (Flavell; 1968, p. 209). For example the child is using the reciprocal operation when he takes rods of different metals but of the same length (here the length is neutralized) in order to study the effect of the kind of metal, and rods of the same metal but with different lengths to study the effect of the length.

Formal thought is, for Piaget, not so much this or that specific behavior as it is a generalized orientation, sometimes explicit and sometimes implicit, towards problem solving: an orientation towards organizing data (combinatorial analysis), towards isolation and control of variables, towards the hypothetical, and towards logical justification and proof (Flavell, 1968, p. 211).

Some adults never fully achieve this last and highest stage of intellectual development, but certainly such thinking as prevails in the formal operations stage is characteristic of scientists and researchers who work with atoms, quarks, and nuclear fission (Pulaski, 1980).

The two most relevant stages of development for this study are the pre-operational and the early concrete operations stages because the majority of grade two students in the schools of Newfoundland are seven years old and studies which have focused on the age-stage relationship (i.e. Piaget's stages) indicate that most seven-year-olds are operating at this level of development.

Having an understanding of what these developmental stages entail, in terms of specific capabilities of the child, one is better equipped to examine the concept of matching. For it is in this process of matching that the child's level of development must be given serious consideration.

The Concept of Matching

> "Learning is a continuous process from birth. The teacher's task is to provide an environment and opportunity which are sufficiently challenging for children and yet not so difficult as to be outside their reach. There has to be the right mixture of the familiar and the novel, the right match to the stage of learning the child has reached."
> [Para. 533 (CACE, 1967)]

This quote from the Plowden Report aptly describes what has been a major concern of educators for many years, matching the curriculum content to the child's level of development. According to Strauss (1972) if the learner possesses the appropriate internal capabilities, it is possible to provide that match by creating external conditions which would facilitate positive vertical transfer.

Good (1977) contends that only the most superficial, fragile kind of knowledge can be gained when the gap is so wide between what is to be learned and the mental structures available for the job (p. 162). The whole idea behind matching is to narrow that gap by finding out what children can do and then using this information as a basis for providing appropriate experiences relating to skill and concept development.

Educators such as Renner and Stafford (1979) say that to truly implement the learning cycle, children must explore concepts at their intellectual level by being exposed to actions and activities that have been constructed on the basis that a particular theory is true and the real basic is school activities that build mental structures which will allow more and more assimilation as children move through the schools. In this respect, writes Good (1977), the nature of the curriculum and how the student is introduced to it should be based on an understanding of the students.

Strauss (1972) refers to this when he says that we must first ascertain the level of reasoning required for a task and then test to see if the child has acquired that level of reasoning. If it exists, the probability of task solution is greater than if the task's solution requires a higher level of operation than the child possesses.

Experiences do not simply happen to the child; rather, they must always be assimilated, which means that they can be effective only if they are not too far beyond the child's current level (Nadelman, 1982, p. 206). A particular mental structure must be present in order for a concept to be comprehended.

To follow through with the Piagetian Model, reference must be made again to that factor which, according to Piaget, contributes to intellectual growth (along with maturation, social transmission, and experience) and which is unique to Piaget's theory — that of "equilibration". An understanding of this process is crucial to the whole idea of matching.

Equilibration refers to a process by which a developing child seeks greater balance at successively higher levels as new learnings are reconciled with the old. A child encountering something new to him actively works at relating it to something he knows. As the new stimulus in turn becomes familiar to him he reaches a new level of equilibrium. This equilibrium results from the interaction of accommodation and assimilation. According to Nadelman (1982), Piaget argues that the child is most motivated to act upon events that are slightly different from those that he has encountered before. Such events then create a state of disequilibrium in the cognitive system; further cognitive action then ensues, and equilibrium is restored at a new, more advanced level (p. 207).

Labinowicz (1980) suggests that Piaget's theory can provide teachers with valuable guidelines for the selection of activities that are within the intellectual capabilities of individual children (p. 165) and, consequently, help ensure a 'match'.

Educators seem to agree that "appropriate" learning experiences should be provided for children regardless of their grade level. In order to have a match, as Lavatelli (1970) points out, "There must be sound theory for intelligent selection, otherwise structured activities could degenerate into busy work"(p. 24). The next section will deal with matching in one area of the curriculum, namely science.

Matching in Science

> "All of the effort to develop scientific literacy is lost ... if students do not encounter content concepts that are on their intellectual level."
>
> (Renner and Stafford, 1979, p. 300)

Classroom teachers are faced daily with decisions about just this sort of concern — what kind of experiences and activities should we provide for children to meet them on their own intellectual level.

In making such decisions it is important to try to suggest those experiences and activities which match as far as is possible the children's abilities and development, and thus give them the best chance of learning (Harlen, Darwin and Murphy, 1974, p. 14).

A survey of primary education in England done by HM Inspectors of Schools had as one of its aims an attempt to quantify the 'degree of match' in various subject areas. The results of the survey revealed a striking pattern. The order of success in matching varied little, with reading, mathematics, writing and physical education being consistently near the top of the scale while at the bottom consistently was science, with geography and history, art and craft not far ahead. (Primary Educationin England, A Survey by HM Inspectors of Schools, 1978, pp. 81-82).

A similar survey carried out in Scotland revealed that in 25% of the classrooms science was more or less neglected and certainly would not be regularly taught as would reading and mathematics which were viewed as important subjects (Learning and Teaching in Primary 4 and Primary 7, A Report by HM Inspectors of Schools in Scotland, 1980).

The low priority given to the teaching of science in Scotland made it impossible for the Inspectors carrying out the survey to determine the extent to which the learning materials represented a good match for the children concerned. Findings such as these raise two questions: (1) Why does science tend to be at the bottom of the scale in terms of teaching time devoted to it? and, (2) Why does it tend to be at the bottom of the scale with respect to matching?

With reference to the latter, Harlen, Darwin and Murphy (1977) contend that learning in science, as in any other subject area, is most likely when activities are matched to a child's way of thinking but also challenge that way of thinking; and they give these as factors which might well be associated with this order of descending success in matching:

1. The order of success in matching is also the order of descending 'importance' of subjects as seen in most people's eyes.

2. It is a reflection of what is important in initial training programmes. Teachers cannot be expected to teach subjects well if their preparation in these subjects has been insufficient.

3. A third factor might well be teachers' own background knowledge. In science we have a situation of pupils having no adequate science experience in the primary school, being deterred by academic science courses in the secondary school and leaving with a dislike of the subject, some to become teachers who perpetuate these conditions.

> 4. A fourth factor relates to the kind of materials which teachers have to help them. At the top end of the matching ratings we find reading and mathematics, for which ready worked out teaching schemes and materials abound. Materials can never replace the sensitive interaction of teachers with pupils which is necessary for matching, but they at least provide the essential resources.
>
> (pp. 57-58)

Leading from these four basic factors is the problem of curriculum content. According to Renner and Stafford (1979), many science textbooks written for elementary school science introduce very abstract concepts, such as the atom: Such concepts are chosen because of adult appeal, but they are of no value to children in the preoperational and concrete operational stages of thought (p. 151). Dietz and Sunal in Seefeldt (1976) point out that according to Piaget, primary-age children are in a preoperational stage of development. Many science concepts and principles are so abstract that only those students who have arrived at a formal operational level can understand them. It is recommended that as science instruction progresses throughout the grades, it should be vertical; that is, each new presentation should build upon concepts already formed.

While noting that the nature of child development has important implications for work with children in science, Jacobson, Bergman and Abby (1980) outline a suggested hierarchy of skills to be developed:

> 1. Children should learn to identify and describe the physical characteristics of what they are perceiving ...
>
> 2. Children ought to be aware of the sense or senses they are using as they examine an object.

3. Children should be encouraged to recognize similarities and differences among objects perceived.

4. Young children should also begin to develop the ability to order materials along some continuum.

5. Materials may be sorted or classified according to various criteria.

6. As children accomplish simple sorting, they should move on to more complex types of classification.

(p. 78)

They further contend that in all science teaching there should prevail an open-endedness, and science lessons should not have conclusions in the sense that there will not be further exploration of a particular subject.

From such theories of cognitive development as that of Piaget, too, are derived implications for teaching as outlined by Gage and Berliner (1979):

1. The educator needs to make a special effort to put himself in the child's place so as to see phenomena and problems in the way the child sees them.

2. Children, particularly in the preschool and early elementary school years, learn especially well from working with concrete objects, materials and phenomena.

3. Theories of sequences of development also lead us to believe that instruction should begin with a "messing around" stage. Children need always to learn the near at hand before they venture out to learn things further from their own experience. (pp. 155-156)

Three distinctive characteristics of children's thinking are outlined by Good (1977) as being:

1. Animism - attributing a consciousness to such things as the sun, moon, trees, stones, air and the like.

2. Artificialism - denotes the child's tendency to believe that things are made for man's benefit.

3. Magic - used to characterize explanations where man caused things to happen, that is, movement of clouds, movement of sun, and the like.

(p. 9)

With specific reference to the teaching of science, Good further points out that teachers helping children learn science should take into consideration the following points: there are wide variations in development levels among children in most classrooms and thus, equally wide variations in their conceptualizing abilities; conceptual learning is tied to developmental level and occurs primarily as a result of a child's internalizing his or her own actions on objects; direct, verbal instruction has little effect in facilitating advancements of developmental levels and, thus, the ability of children to conceptualize problems beyond their current developmental abilities; and finally, science is an attempt to make more sense out of one's environment by manipulating portions of that environment at a difficulty level consistent with one's conceptual abilities (p. 220).

The authors of the Science 5/13 program, Ennever et. al., (1972) used Piaget's theory as a basis for the development of activities for their program. One of their major concerns for the program was that learning experiences be matched with the particular stages of development (p. 15). They contend that experiences must ideally be not only well suited to a child's point of mental development but also ones which are interesting and real to him. Thus it is important for a teacher to have some idea of the stage of development of each child in relation to any specific topic or set of problems, and to be able to find suggestions, if necessary, for suitable activities (p. 15).

It can be seen then, that many educators feel that a 'match' between curriculum and children's capabilities is essential for learning across the curriculum. With respect to the science curriculum in particular there is a concurrence of opinion that an understanding of child development is crucial to planning curriculum content and process, and that there is a need for the match in science, which seems to have been neglected.

The literature examined supports the claim stated earlier. Piaget's experimental work and the comprehensive theory which has resulted represents a major advance in our understanding of how children learn and develop. This theory is particularly relevant to science teaching, because it deals with the capabilities of children at different levels to perform certain logical operations which are directly related to some of the processes of science, and finally, the process of equilibration, uniquely Piaget's, is central to the idea of matching. In fact, Piaget has described the development of science concepts through four discrete stages: the sensori-motor stage, the preoperational stage, the concrete stage and the formal operations stage.

When a teacher truly understands the developmental stages of children he will be able to ask himself the following questions about a child and an activity, to explore the likelihood of a match or a mismatch:

1. Does the child have the ideas and abilities

which are necessary prerequisites for tackling the activity?

2. Does the activity provide opportunity for the child to develop existing ideas further, without demanding too large a change in ways of thinking?

3. Are the experiences available to the child in a form which is suitable for him?

4. Are the organization, social grouping and other conditions of working, suitable?

5. What approach by the teacher will be of most help to him?

(Harlen, Darwin and Murphy, 1977, p. 160).

CHAPTER III

METHODOLOGY

Methodology for Sample Selection and Analysis

In order to have a match between the stages of development and the activities of the STEM science program, the activities should require the specific capabilities of these stages and levels of cognitive development.

Piaget identifies four basic stages in the development of mental structures. In order to examine the activities in the STEM science program in the light of Piaget's stages, it is necessary to focus specifically on the characteristics of the different stages, which are significant for this particular study. The preoperational and concrete operations stages are examined in some detail in terms of their characteristics. (Extensive reference is made to the objectives, for these stages, of the science 5/13 Program.)

The children who use the grade two STEM science program will be seven years old generally. A smaller group of them will be six or eight years old but will still be at the preoperational stages in their thinking in general. A lesser examination, in terms of characteristics, will be made of the formal operations stage as well (Stage 3 of Science 5/13), however, so that in cases where an activity requires abilities of this stage it can be identified as such.

The latest statistics available from the Provincial Department of Education regarding the age of grade two children in the province came from the Statistical Supplement to the Annual Report of the Department of Education for the School Year Ending, June 30, 1973. This report indicates that for that academic year 61.7% of the total number of grade twos in the province were aged seven by December 31, 1972. There is good reason to believe that a large number of the other 36.3% would have been seven by the end of that academic year because statistics for the year showed that 23% of the grade three students that year were seven years old by December 31, 1972. The information could lead one to deduce that a similar situation would have existed in 1973, thereby having many grade twos turn seven by the end of the academic year. According to Beard (1969), the preoperational stage extends from approximately 2 to about 7 or 8 years, the concrete operations stage extends from about 7 or 8 to about 11½ years and the formal operations stage extends from about 11½ to about 14 or 15 years.

For the purpose of this study the specific abilities characteristic of these three stages are taken from a combination of Copeland (1974), Beard (1969), and Science 5/13 (1972). The last named source used Piaget's stages as the basis for its breakdown into stages.

Ennever et. al., (1972) in With Objectives in Mind (Guide to Science 5/13) indicate their adherence to Piaget's stages of development:

> "Since we follow quite closely Piaget's ideas about development, our stages 1, 2, and 3 have similar properties to Piaget's stages, namely:
>
> 1. Each stage extends and builds upon the one before and then forms the necessary foundation for the next stage.
>
> 2. Children pass through these Stages in the same order 1-2-3, though the rate at which they pass

through them varies between individuals.

3. Age is no guide to stages for a particular child. It is only when referring to the average of a large number of children that Stage can be roughly related to age."

(p. 10)

In order to carry out this study, activities from the Grade two STEM Science Program (Teachers' Edition) were enumerated and the total number found to be 270. The distribution of activities into catagories was found to be: Space-29, Time-41, Energy-39, Matter-49, Living Things-74, Plants and Animals in Relation to Space, Time, Energy and Matter-38. Random sampling by use of a table of random numbers from Glass and Stanley's Statistical Methodsin Education and Psychology (1970), was used to select 25% of these activities for analysis.

Each activity for the sample is examined as follows: (1) A description of the activity, according to the text, is given, (2) then follows a discussion of what is required of the child in order to carry out the activity, and finally (3) an examination of these requirements, in terms of the abilities characteristic of the stages, is undertaken and the activity is rated as suitable (i.e. a good match) or unsuitable (i.e. not a good match).

After all activities have been examined in this manner, it is possible to discuss the overall suitability of the text for Grade Two students, and to make certain recommendations with respect to the present program.

The characteristics of the three more relevant stages for this study (preoperational, concrete and formal) are given here in outline form. To overcome redundancy, which is inevitable when quoting from three sources, an attempt is made to omit repetitions of characteristics so that they do not appear more than once.

Characteristics of the Preoperational, Concrete Operations and Formal Operations Stages

A. Preoperational Stage (2-7 or 7½ years)

1. the ability to represent one thing by another increases speed and range in thinking, particularly as language develops; but because language is acquired slowly and does not immediately take the place of action, thinking remains to a considerable degree tied to the children's actions
(Beard, 1969, p. 39).

2. the reasoning of young children ... moves from particular to particular, without generalization and without logical rigour. Piaget calls such reasoning transduction. Observations show that there is development in thinking within the stage, but that transduction is typical of reasoning in children until operational thinking is achieved
(Beard, 1969, p. 46)

3. in this stage children unconsciously extend their own immediate point of view to all possible points of view. This characteristic of their thinking Piaget terms realism. It is seen when they suppose that other people see the same view of a model as they do
(Beard, 1969, p. 47).

4. it is as a result of realism that children explain events in the world by artificialism. Children constantly assert that events in the world are caused by people
(Beard, 1969, p. 47).

5. children attribute characteristics of life to objects ... and suppose that all objects are alive and can feel

(Beard, 1969, p. 48)

6. the child's ideas of causality and force are based on his own physical or psychic activity

(Beard, 1969, p. 48)

7. early in this stage all but the simplest spatial relations are found difficult

(Beard, 1969, p. 49)

8. in the intuitive stage (which extends from about 4½ to about 7 years) there is a development which enables children to begin to give reasons for their beliefs and actions and to form some concepts, but their thinking is still not operational). In the absence of mental representation their thinking is dominated by immediate perceptions, and suffers from the variability typical of perception. Thus, although it is possible with practice to coordinate a number of perceptions of the same object by a form of perceptual activity, it is not possible to achieve the stability and reversibility of conceptual thinking which derives from mental operations

(Beard, 1969, p. 57-58)

9. children make no effort to stick to one opinion or any given subject

(Beard, 1969, p. 58)

10. there is a lack of direction in children's thinking

(Beard, 1969, p. 58)

11. thinking remains egocentric

(Beard, 1969, p. 59)

12. they are unable to compensate two relations, or to make even the simplest relations between relations

(Beard, 1969, p. 59)

13. children begin to imitate reality

(Beard, 1969, p. 61)

14. at the later ages, during this stage, children give more artificialist explanations and fewer animistic or magical ones...; they cease to believe that their own activity has the power to make objects move... but shift the centre of force to the objects - believing that they move of their own accord or, alternatively, that they choose to obey man or God

(Beard, 1969, p. 63)

15. they are unable to hold in mind more than one relation at a time. They judge one group of objects more numerous than another simply because it covers more space, disregarding the number although they may previously have matched the objects in two equal lines. They are incapable of reversing the movement of the objects to 'see' them in two equal lines again (Beard, 1969, p. 65)

16. conservation of quantities is not understood. Piaget found that children he tested understood conservation of number and substance at about six, of weight and area at about eight, but of volume not until about ten years (Beard, 1969, p. 67)

17. children at this stage have no real conception of measurement (Beard, 1969, p. 67)

18. making series of all kinds presents difficulties to children in this stage because they can compare only two elements at a time (Beard, 1969, p. 68)

19. the relation of a whole with its parts, or a class with sub-classes presents difficulties

(Beard, 1969, p. 69)

20. the child's conception of space, though closely tied to his actions, enables him to take account of proximity, separation, order and continuity; consequently, the parts of the body are drawn in correct order, for example (Beard, 1969, p. 70)

21. the formation of mental images, or other representation of shapes, results from the abstraction of properties of shapes during a child's handling of objects. A lack of adequate mental representation is evident in copying order (Beard, 1969, p. 71)

22. projective properties of shape, such as shadows and sections, or the Euclidean properties of angles, parallels, similarities, and so on are rarely understood by young children
(Beard, 1969, p. 72)

23. it is a stage of representation or symbolism. Words are being used to represent things. The child begins to manipulate symbols or representations of the physical world in which he lives
(Beard, 1969, p. 26)

24. they build up appreciation of relationships within a shape, through memories of exploration of it
(Beard, 1969, p. 71)

25. from a developmental standpoint, children are able to learn multiplication at the same time that they are able to learn addition, approximately 7 years of age
(Copeland, 1974, p. 45)

26. around five or six, children make the classification by shape or color or both. Classifying by size is somewhat more difficult
(Copeland, 1974, p. 54)

27. activities for rational counting are appropriate prior to the concrete operational stage
(Copeland, 1974)

28. from six and one-half to nine years of age, children have an intuitive idea that time and velocity are inversely proportional but it is not until eight and one-half to nine years that they are able to coordinate durations with the order of events
(Copeland, 1974, pp. 168-169)

29. in the first part of the preoperational period there is semilogic of one-way mappings
(Copeland, 1974, p. 26)

30. children have not reached the stage of reversibility of thought necessary for the conservation of number concept involved in such problems as ; 3 plus 2 equals 5, 3 plus □ equals 5, □ plus □ equals 5
(Copeland, 1974, p. 75)

31. according to Copeland (1974) until the reversibility of thought is achieved (from whole to parts to whole again) the logic of inclusion and addition of classes as operations cannot be learned

32. the reversibility involved in multiplication and division is impossible for many children below the operational level of approximately seven years of age (Copeland, 1974, p. 142)

33. logical justification is at a very imperfect stage up to the age of 7 or 8 and there must be a long transitional period of learning before deduction can be handled properly (Copeland, 1974, p. 128)

34. to teach a line segment as a set of points in primary grades is to teach without meaning (Copeland, 1974, p. 162)

The developmental stage 1, as set forth in Science 5/13, includes some preoperational and some early concrete operational thought, but chiefly the transition between the two (Ennever et. al., 1972, p. 10). The following are some of the characteristics for that stage, taken from With Objectives in Mind, (of the Science 5/13 program):

35. willingness to handle both living and non-living material

36. enjoyment in using all the senses for exploring and discriminating

37. desire to find out things for oneself

38. awareness that there are various ways of testing out ideas and making observations

39. interest in comparing and classifying living or non-living things

40. enjoyment in comparing measurements with estimates

41. willingness to wait and to keep records in order to observe change in things

42. awareness of changes which take place as time passes

43. recognition of common shapes - square, circle, triangle

44. recognition of regularity in patterns

45. ability to group things consistently according to chosen or given criteria

46. awareness of change of living things and non-living materials

47. recognition of the action of force

48. ability to group living and non-living things by observable attributes

49. ability to distinguish regularity in events and motion

50. appreciation that things which are different may have features in common

51. ability to predict the effect of certain changes through observation of similar changes

52. formation of the notions of the horizontal and the vertical

53. development of concepts of conservation of length and substance

54. awareness of the meaning of speed and of its relation to distance covered

55. ability to find answers to simple problems by investigation

56. ability to make comparisons in terms of one property or variable

57. awareness that more than one variable may be involved in a particular change

58. ability to discriminate between different materials

59. ability to use displayed reference material for identifying living and non-living things

60. awareness of sources of heat, light and electricity

61. appreciation that ability to move or cause movement requires energy

62. ability to use books for supplementing ideas or information

63. ability to record events in their sequences

64. ability to use representational symbols for recording information on charts or block graphs

65. ability to tabulate information and use tables

66. ability to record impressions by making models, painting or drawing

67. awareness of cause-effect relationships

68. awareness of seasonal changes in living things

69. awareness that the apparent size, shape and relationships of things depend on the position of the observer

B. Concrete Operations Stage (7-11½ years)

70. physical actions begin to be 'internalized' as mental actions or 'operations' (Beard, 1969, p. 76)

71. egocentricity decreases substantially and genuine co-operation with others replaces isolated play or play 'in the company of others' which is characteristic of the earlier periods (Beard, 1969, p. 77)

72. they (the children) can classify, or make series, in two or more ways simultaneously (Beard, 1969, p. 77)

73. there is a further diminution in the number of symbolic games (Beard, 1969, p. 83)

74. limitations in verbal reasoning appear to be characteristic of this period:

    1. children consider one statement at a time, when required to use verbal propositions instead of objectives (Beard, 1969, p. 85)

2. they see only a special case without appreciating the need to express a general law

(Beard, 1969, p. 85)

3. they fail to see a hidden meaning but assimilate some familiar item to an experience which they already understand or to superficial similarity

(Beard, 1969, p. 87)

4. they experience difficulty with providing a meaningful definition

(Beard, 1969, p. 87)

75. understanding of topological concepts is completed and projective concepts, such as perspective and sections are gradually mastered

(Beard, 1969, p. 88)

76. children begin to use some Euclidean concepts: measures of length, area and angles can be applied intelligently. Properties such as numbers of sides or angles, or parallel sides of a figure can be observed correctly

(Beard, 1969, p. 88)

77. in measuring, children of this period learn first to use a large intermediary object and only later use a smaller object as unit

(Beard, 1969, p. 91)

78. they cannot use scales or balances

(Beard, 1969, p. 92)

79. they fail to realize that volume or capacity is conserved when a quantity of sand or liquid is transferred from one container to another

(Beard, 1969, p. 92)

80. they do not adequately understand the concept of weight

(Beard, 1969, p. 92)

81. this stage marks the beginning of logico-mathematical thought. The child is said to be "operational" in his thinking. The necessary logical thought is based in part on the physical manipulation of objects

(Beard, 1974, p. 26)

82. the concept of conservation or invariance is a basic characteristic of this stage

(Beard, 1974, p. 27)

83. operations at the concrete level include, according to Piaget, those of putting objects together to form a class, separating a collection into subclasses, ordering elements in some way, ordering events in time, and so on (Beard, 1974, p. 29)

84. the necessary concepts of change of position, conservation, and an external reference system as a prelude to measurement do not appear for many children until age seven or eight (Copeland, 1974, p. 259)

85. beginning at the concrete level, children are introduced to place value (Copeland, 1974)

86. measurement in its operational form (with immediate insight rather than by trial and error) is not achieved until eight or eight and one-half years of age. (Copeland, 1974, p. 269)

87. telling time requires an intellectual construction not usually found in children until nine or ten years of age (Copeland, 1974, p. 177)

88. while the adult realizes that instruments used to tell time can move at different speeds to measure the same time, the preoperational child cannot and will not until nine or ten years of age (Copeland, 1974, p. 179)

89. the child does not understand the inclusion relation (Copeland, 1974, p. 59)

90. the child can classify by some property, such as color or shape. He is partially successful but does not realize that there is a hierarchy of classification (Copeland, 1974, p. 55)

91. the ability to seriate or order, such as from smallest to largest, or to count at the operational level, that is, with true understanding of the inclusion relations involved, develops usually at seven to eight years of age (Copeland, 1974, p. 80)

92. some children will have understanding of time at eight to nine years of age. Others will not be ready for true understanding of time at ten years of age (Copeland, 1974, p. 176)

93. at this stage children begin to use words that express mathematical relations between two objects, such as "more" or "less", "taller" or "shorter", "heavier" or "lighter"

(Copeland, 1974, p. 188)

94. the child is becoming more aware of the relations that exist between separate events

(Copeland, 1974, p. 205)

95. children are not ready to work at the abstract level. They are very much a part of the physical world

(Copeland, 1974, p. 208)

The developmental stage 2, as set forth in Science 5/13, represents the stage of concrete operational thought and it is the main way of thinking for this stage (Ennever et. al., 1972, p. 10). The following are some of the characteristics for that stage, taken from With Objectives in Mind, (of the Science 5/13 program):

96. willingness to observe objectively

97. willingness to examine critically the results of their own and others' work

98. preference for putting ideas to test before accepting or rejecting them

99. enjoyment in developing methods for problems or testing ideas

100. awareness of internal structure in living and non-living things

101. ability to construct and use keys for identification

102. recognition of similar and congruent shapes

103. awareness of symmetry in shapes and structures

104. ability to classify living things and non-living materials in different ways

105. ability to visualize objects from different angles and the shape of cross-sections

106. appreciation of measurement as division into regular parts and repeated comparisons with a unit

107. appreciation that comparisons can be made indirectly by use of an intermediary

108. development of concepts of conservation of weight, area and volume

109. understanding of the speed, time, distance relation

110. ability to frame questions likely to be answered through investigations

111. ability to investigate variables and to discover effective ones

112. appreciation of the need to control variables and use controls in investigations

113. ability to choose and use either arbitrary or standard units of measurement as appropriate

114. ability to use representational models for investigating problems or relationships

115. knowledge of sources and simple properties of common forms of energy

116. knowledge of ways to investigate and measure properties of living things and non-living materials

117. skill in devising and constructing simple apparatus

118. ability to select relevant information from books or other reference material

119. ability to use non-representational symbols in plans, charts, etc.

120. ability to use histograms and other simple graphical forms for communicating data

121. ability to construct models as a means of recording observations

122. awareness of sequences of change in natural phenomena

123. awareness of structure-function relationships in parts of living things

131. he can operate with the form of an argument and ignore its empirical content
(Copeland, 1974, p. 30)

132. he can use the procedures of the logician or scientist - a hypothetic-deductive procedure that no longer ties his thoughts to existing reality
(Copeland, 1974, p. 30)

133. at this stage it is possible to establish any relations between classes bringing together elements singly, in twos, threes and so on
(Copeland, 1974, p. 31)

134. during this stage the child is able to establish true conventional reference systems that enable him to compare distances and positions simultaneously
(Copeland, 1974, p. 279)

135. the child is at the abstract level
(Copeland, 1974, p. 285)

136. children discover that "volume" is not just the interior "contained" by some three-dimensional object such as a brick, but that space exists in its own right whether occupied by the brick or not occupied by the brick
(Copeland, 1974, p. 302)

The developmental stage 3, as set forth in Science 5/13, represents the transition from concrete operational to formal operational thought. Formal thought is characterized by abilities not previously possible, which derive from the power to think about what is abstract and not only what is actual (Ennever et. al., 1972, p. 11). The following are some of the characteristics for that stage, taken from <u>With Objectives in Mind</u>, (of the Science 5/13 program):

137. recognition of the need to standardize measurements

138. willingness to extend methods used in science activities to other fields of experience

124. awareness of the changes in the physical environment brought about by man's activity

125. appreciation of the relationships of parts and wholes

126. appreciation of how the form and structure of materials relate to their function and properties

127. recognition of the role of chance in making measurements and experiments

C. Formal Operations Stage (11½ - 14 or 15 years)

128. cooperation with others is apparent at this stage. Consideration of many viewpoints gives adolescent thinking a new flexibility

1. The adolescent can accept assumptions for the sake of argument.
2. He makes a succession of hypotheses which he expresses in propositions and proceeds to test them.
3. He begins to look for general properties which enable him to give exhaustive definitions, to state general laws and to see common meanings in proverbs or other verbal material.
4. He can go beyond the tangible, finite and familiar in spatial concepts to conceive the infinitely large or infinitely small, and to invent imaginary systems.
5. He becomes conscious of his own thinking, reflecting on it to provide logical justification for judgements he makes.
6. He develops an ability to deal with a wide variety of complex relations such as proportionality and correlation.

(Beard, 1969, pp. 98-99)

129. some misconceptions relating to conservation of volume appear to persist into adolescence among a substantial number of children (Beard, 1969, p. 107)

130. the child can now reason or hypothesize with symbols or ideas rather than needing objects in the physical world as a basis for his thinking (Copeland, 1974, p. 30)

139. appreciation that classification criteria are arbitrary

140. ability to distinguish observations which are relevant to the solution of a problem from those which are not

141. ability to estimate the order of magnitude of physical quantities

142. familiarity with relationships involving velocity, distance, time, acceleration

143. ability to separate, exclude or combine variables in approaching problems

144. ability to formulate hypotheses not dependent upon direct observation

145. ability to extend reasoning beyond the actual to the possible

146. ability to distinguish a logically sound proof from others less sound

147. ability to begin to identify the essential steps in approaching a problem scientifically

148. ability to design experiments with effective controls for testing hypotheses

149. ability to construct scale models for investigation and to appreciate implications of changing the scale

150. knowledge that chemical change results from interaction

151. knowledge that energy can be stored and converted in various ways

152. knowledge that properties of matter can be explained by reference to its particular nature

153. knowledge of certain properties of heat, light, sound, electrical, mechanical and chemical energy

154. ability to apply relevant knowledge without help of contextual cues

155. ability to select the graphical form most appropriate to the information being recorded

156. ability to use analogies to explain scientific ideas and theories

157. recognition that the ratio of volume to surface area is significant

158. recognition that energy has many forms and is conserved when it is changed from one form to another

159. ability to draw from observations conclusions that are unbiased by preconception

160. willingness to accept factual evidence despite perceptual contradictions

161. awareness that unstated assumptions can affect conclusions drawn from argument or experimental results

The identification of the characteristics of the preoperational, concrete operational and formal operational stages of development in this manner, serves to facilitate the examination and analysis of the activities selected from the Grade Two STEM Science Program. This is done with the assumptions that (1) most grade two children are seven year olds, and (2) most seven-year-olds are in the later stages of pre-operational thinking, the transitional stage from pre-operational to concrete, or the early stage of concrete thought, such as is given in developmental Stage 1 of the Science 5/13 Program.

CHAPTER IV

ANALYSIS OF SAMPLE OF ACTIVITIES FROM GRADE TWO STEM SCIENCE PROGRAM

Introduction

This chapter gives an analysis of each activity contained in the selected sample from the Grade Two STEM Science Program. The procedure for analyzing these activities, as outlined in Chapter III, is as follows:

1. a description of the activity
2. an outline of the intellectual demands inherent in each activity, and
3. an analysis of the activity according to Piaget's Stages.

It will be recalled that the pre-operational stage extends from approximately age 2 to about 7 or 8, the concrete operations stage from about age 7 or 8 to about age 11½ years, and the formal operations stage from about age 11½ to about age 14. These three stages of development correspond approximately to stages 1, 2 and 3 of the Science 5/13 Program.

A Grade Two child who is 7 years old will generally have passed through the pre-operational stage of development (or Stage 1 of the Science 5/13 Program) but will generally not have completely attained the concrete operations stage (or Stage 2 of of the Science 5/13 Program). Normally, Grade Two children will be in a transitional stage between pre-operational and concrete operations (or between Stage 1 and Stage 2 of the Science 5/13 Program). A child in this transitional stage can not be considered to be at the stage of development which will enable him to handle adequately activities which are deemed suitable for children at the concrete operations stage (age 7 or 8 to age 11½ or Stage 2 of the Science 5/13 Program), and particularly if such activities demand abilities beyond the early part of concrete operations. This point is reinforced by Honstead writing in Frost (1968) who claims that "When the child reaches the age of approximately nine to twelve, he moves from intuitive thought into the final phase, that of the attainment of concrete operations" (p. 139). It can be inferred from this that the average child below nine years of age will not have completely attained the concrete operations level of development.

It will be further recalled that most Grade Two children are seven years of age. Bearing in mind the level of difficulty of certain activities and the range of abilities of seven-year-olds, some of whom might well be in the early concrete operations stage for the purpose of activity analysis, two categories are established:

1. Activities which clearly require functioning at the advanced stage of concrete operations or beyond will be categorized as unsuitable for the Grade Two child.
2. Activities which require functioning at the pre-operational or early concrete operations stages will be categorized as suitable for the Grade Two child.

The activities are analyzed according to units in the text, from which they were randomly selected, there being six units in all.

The page of the Grade Two STEM Science Textbook (Teachers' Edition) from which each activity is selected is noted. All activities are numbered consecutively. In the analysis of each activity reference is made to characteristics listed in Chapter III with the relevant number of the characteristic and page location.

Analysis of Activities from Unit: LIVING THINGS

1. ACTIVITY (p. 6)

Have the children look at the 36 seeds shown on the page. Ask: "Are any of the seeds alike in some way?" "Which seeds?" As the children suggest the numbers of seeds that are alike, list their responses on the board. Encourage the children to suggest titles for each list of seeds. Examples: "ROUND"; "BROWN"; "SMALL"; "LARGE". After the lists are completed, ask: "Are all the seeds alike?" and "What is different about the seeds?" (size, shape, color)

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity, the child is expected to observe and examine the seeds. Using the information he receives from these observations, the child is then to classify and compare the seeds. The whole activity is based on the child's ability to perceive, look for differences and similarities and, in doing so, to classify.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), at around five or six, children make the classification by shape or color or both (Characteristic # 26, p. 39). Also, one of the characteristics of the Science 5/13 Program for Stage 1 is given as being: ability to group living and non-living things by observable attritubes (Characteristic # 48, p. 41). Since the child is being asked to group by observable attributes such as color, size and shape, in this activity, then the activity can be seen as appropriate for a child at the Grade Two level.

This activity can be categorized as suitable.

2. ACTIVITY (pp. 6-7)

Distribute an acorn, a walnut, and 5 assorted seeds to each small group of children. Make sure each group has the same kinds of seeds. Have the children place each seed on a piece of centimetre-squared graph paper. Give each child a chance to draw around the squares that one of the seeds covers up. After the children have completed enclosing the squares, have them count the number of squares covered by each seed. Then have each group tell the number of squares covered by each seed. Write each group's responses on the board.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity, the child is expected to compare the sizes of the seeds and nuts by counting the number of centimetre-squares each covers. The comparisons to be made will be based on one property or variable-size.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The characteristics which would seem to indicate that this activity is appropriate for a child at the Grade Two level appear in the list of characteristics for Stage 1 of the Science 5/13 Program:

1. ability to find answers to simple problems by investigation (Characteristic # 55, p. 41)
2. ability to make comparisons in terms of one property or variable (Characteristic # 56, p. 41)
3. ability to use representational symbols for recording information on charts (Characteristic # 64, p. 42)
4. ability to record impressions by making models, painting or drawing (Characteristic # 66, p. 42)

Placing the seed or nut on the squared paper and then tracing around it would be activities that a child at the pre-operational level could handle, providing his psychomotor development has been normal. His everyday experiences would help him have the capabilities necessary for this activity.

According to Copeland (1974), activities for counting are appropriate prior to the concrete-operational stage (Characteristic # 27, p. 39) so the counting involved in this activity could be handled by a child at the pre-operational level of development (i.e. Grade Two).

This activity can be categorized as suitable.

3. ACTIVITY (p. 12)

The photographs on these pages show different foods: a bowl of apples, oranges, and seeded grapes; a bowl of popcorn; a bowl of nuts; a plate of unpitted olives and small gherkin pickles; a basket of rolls with seeds; a tossed salad of cucumbers, tomatoes, and lettuce; a fruit salad of strawberries, bananas, and seedless grapes; and a bowl of dates, figs, and prunes.

Help the children identify the seeds. Take the point that most of these foods, with the exception of the seedless grapes and lettuce, have seeds in them.

INTELLECTUAL DEMANDS OF THE ACTIVITY

This particular activity would be carried out at the beginning of a lesson and after the children had had a previous activity where they had been involved with tasting seeds and collecting other seeds.

In order to carry out this activity the children would need to be able to recall their previous experiences with seeds and also be able to appreciate that things which are different may have features in common.

ANALYSIS ACCORDING TO PIAGET'S STAGES

In order to identify the foods with seeds in them, the child will, according to Beard (1969), be forming a mental image which results from the abstraction of properties from objectives during the child's manipulation of them. According to Beard (1969), a child is able to do this at the pre-operational stage (Characteristic # 21, p. 38).

The characteristics which would seem to fit this activity in Science 5/13 appear in the list for Stage 1. These characteristics are:

1. ability to group things consistently according to chosen or given criteria (Characteristic # 45, p. 41)
2. ability to group living and non-living things by observable attributes (Characteristic # 48, p. 41)
3. appreciation that things which are different may have features in common (Characteristic # 50, p. 41)
4. ability to find answers to simple problems by investigation (Characteristic # 55, p. 41)

It can be assumed that a child at the Grade Two level will be able to handle this particular activity.

This activity can be categorized as suitable.

4. ACTIVITY (p. 14)

The eight small pictures at the top of these pages show: orange seeds, peanuts, popcorn, olive pits, sesame seeds, banana seeds, cucumber seeds, and date pits.

Help the children identify these pictures and then answer the questions.

> *Which can you eat?
> *Why?
> *Which can't you eat?
> *Why?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity with the teacher's guidance the child must know that certain things are acceptable for eating in his particular environment and some things are not.

ANALYSIS ACCORDING TO PIAGET'S STAGES

Beard (1969) writes that in the intuitive stage, there is a development which enables children to begin to give reasons for their beliefs (Characteristic # 8, p. 37). Consequently, it should not be too difficult for the child at the pre-operational level to name the things which can be eaten from this list and also to tell why.

The characteristics from Science 5/13 which would seem to suggest that this activity is appropriate for a child at Stage 1 are:

1. ability to group things consistently according to chosen or given criteria (Characteristic # 5, p. 41)
2. ability to group living and non-living things by observable attributes (Characteristic # 48, p. 41)
3. appreciation that things which are different may have features in common (Characteristic # 51, p. 41)

It can be assumed that this activity is appropriate for a child at the Grade Two level.

This activity can be categorized as suitable.

5. ACTIVITY (p. 17)

When you are sure that the children understand the bar graph on page 17, distribute a copy to each child. Give each group the seed pods and fruits. (It probably would be easiest to cut apart these items ahead of time.)

Have each group determine the number of seeds in each item. Then have each child record that number on his or her own chart. Tell the child to use a different color crayon for each item.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity a child is expected to count seeds and be able to record his count on a bar graph by using a different colored crayon for each item.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), activities for rational counting are appropriate prior to the concrete operational stage (Characteristic # 27, p. 39). Consequently, the part of the activity which involves rational counting should not be too difficult for a child at the Grade Two level.

Science 5/13 lists as one of its characteristics for Stage 1, the ability to use representational symbols for recording information on charts or block graphs (Characteristic # 64, p. 42). This would indicate that the recording which is involved for this particular activity can be done by children at Stage 1 (in this case Grade Two).

This activity can be categorized as suitable.

6. ACTIVITY (p. 17)

This page shows an apple tree that is loaded with apples. The apples are being picked and put in baskets. Now that the children have counted the seeds in a real apple, ask them to think about the questions on the page:

*How many seeds in an apple?
*How many apples on a tree?
*How many seeds on a whole tree?

Ask them if they can think of any reasons why not all of these seeds will become plants?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity, the child is expected to conceive of the number of apples on a tree, the number of seeds in one apple and finally the number of seeds on the whole tree. A degree of estimation and multiplication is involved here and to think of the reasons why some seeds will not become plants requires a level of reasoning and logic.

ANALYSIS ACCORDING TO PIAGET'S STAGES

From a developmental standpoint, children are able to learn multiplication at the same time that they are able to learn addition, approximately seven years of age (Copeland, 1974, p. 145). So they are able at the pre-operational stage, to multiply. However, for this activity, the child is not being asked to carry out the multiplication, but rather to think about the quantity that would result if one were to multiply.

According to Copeland (1974), children are not ready at the concrete operational stage to work at the abstract level (Characteristic # 95, p. 45). This activity becomes very abstract when the child reaches the stage in the activity where he has to rely on his thoughts with respect to the quantity of seeds on the tree, for the numbers involved become too cumbersome for the child at even the concrete operational stage to deal with.

It can be assumed, then, that this activity would be too difficult for a child at the Grade Two level.

This activity can be categorized as unsuitable.

7. ACTIVITY (p. 18)

Bring a weed such as red-root pigwood, curly duck, or goldenrod to class. Try to get a weed that has many seeds. Divide the class into small groups. Give each group a part of the weed. Have the children count all the seeds they can find. You could bring other weeds to class. Help the children to record the number of seeds in each weed to find out which weed produces the most seeds.

INTELLECTUAL DEMANDS OF THE ACTIVITY

This activity involves comparing sets of seeds by first counting the seeds in each different weed and then recording the number of seeds in each weed.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974) activities for rational counting are appropriate prior to the concrete-operational stage (Characteristic # 27, p. 39). Therefore, the counting involved in this activity can be done by a child at the pre-operational stage of development and thus Grade Two.

The Science 5/13 Program gives as one of its characteristics, the ability to make comparisons in terms of one variable (Characteristic # 56, p. 41). Since this characteristic is in Stage 1 of the program, it would follow that a child at the pre-operational stage would be ready to do the necessary comparing which is involved in this activity.

Finally, the Science 5/13 Program lists as one of its characteristics for Stage 1, that children acquire the ability to record events (Characteristic # 63, p. 42). This would indicate that the pre-operational child would be ready for that part of the acitivity.

This activity can be categorized as suitable.

8. ACTIVITY (p. 19)

Take the children outdoors after dandelions have gone to seed. Each child should have a toothpick and scissors. Help the children cut off a dandelion stem near its base and below the fruiting head. Then have them pick off one fruit and put it into the large end of the hollow dandelion stalk, seed first. (If they have difficulty, show them how to push the fruit into the stalk with a toothpick.) Let them blow the fruit up into the air.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity the child is expected to use observation and inference, to learn something about wind currents.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The Science 5/13 Program lists the following characteristics for Stage 1:

1. recognition of the action of force (Characteristic # 47, p. 41)
2. ability to distinguish regularity in events and motion (Characteristic #49, p. 41)
3. ability to find answers to simple problems by investigation (Characteristic # 55, p. 41)
4. appreciation that ability to move or cause movement requires energy (Characteristic # 61, p. 41)
5. awareness of cause-effect relationships (Characteristic # 67, p. 42)

These characteristics are also those required for this particular activity, indicating that the activity can be carried out by the average Grade Two child.

This activity can be categorized as suitable.

9. ACTIVITY (p. 22)

Suppose all the seeds from a plant scatter, but they don't get planted, eaten or smashed. Are they still alive?

INTELLECTUAL DEMANDS OF THE ACTIVITY

This activity requires the child to do abstract thinking and reasoning.

ANALYSIS ACCORDING TO PIAGET'S STAGES

Since there is a lack of direction in children's thinking at the pre-operational stage (Beard, 1969, p. 58), the child at this level may experience difficulty with the reasoning involved unless he has some prior knowledge about the subject.

According to Copeland (1974) the child at the concrete operational stage is becoming more aware of the relations that exist between separate events (Characteristic # 94, p. 45), but is not ready to work at the abstract level and is very much a part of the physical world (Characteristic # 95, p. 45). The abstract thinking and reasoning involved in this activity would be beyond the capabilities of the Grade Two child.

This activity can be categorized as unsuitable.

10. ACTIVITY (p. 24)

Have the children follow the directions on page 25: "Plant the same number of seeds in cups A and B. Put one where it is cold, like winter. Put the other one where it is warm, like summer. Water them for two weeks. Now compare. What happened to the seeds?"

The children should work in small groups. Each group should plant two seeds in each cup. Label the cups "A" and "B". Have them place cup A in a freezer and cup B under a box. Put cup B in the warmest part of the classroom. Water the plants for two weeks. Ask the children to make a prediction about what will happen to the seeds in each cup.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity, the child is expected to predict what will happen to the seeds in the different environments over a two-week period. At the end of the two-week period, the child is expected to infer, from what has happened, that a seed needs warmth as well as moisture in order to germinate.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Beard (1969), children in the early stage of concrete operations see only a special case without appreciating the need to express a general law (Characteristic # 74, p. 43).

However, Science 5/13 lists as some of the characteristics for Stage 2 (Piaget's concrete operational stage):

1. knowledge of sources and simple properties of common forms of energy (Characteristic # 115, p. 46)
2. awareness of sequences of change in natural phenomena (Characteristic # 122, p. 46)
3. awareness of structure-function relationships in parts of living things (Characteristic # 123, p. 46)

These characteristics indicate that it is possible for a child at the concrete operational stage to carry out this activity. For if a child is expected to have knowledge of sources and properties of forms of energy and an awareness of sequences of change in natural phenomena, and an awareness of structure-function relationships in parts of living things; then it should follow that he is able to make inferences about natural phenomena based on what he observes over a two-week period and also make predictions about what will happen in the two different environments before it really occurs. One can assume, then, that this activity would not be a good match for a child at the Grade Two level.

This activity can be categorized as unsuitable.

11. ACTIVITY (p. 25)

Seeds such as grains, grasses and corn do not split as do lima beans. Instead, they are of one piece, and the embryo has to force its way out of the seed. Have the class plant some of these seeds. Then dig one up each day to see how the embryo of these seeds manages to sprout.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity children have to classify and infer following observation.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Beard (1969), there is a development in the pre-operational stage which enables children to begin to give reasons for their beliefs, and during this period their thinking is dominated by their perceptions (Characteristic # 8, p. 37). At later ages, during this stage, children give more artificialist explanations and fewer magical ones (Characteristic #14, p. 38). With this level of reasoning a child at the pre-operational stage should be able to see, through observation, that the embryo of these seeds manages to sprout.

Some of the characteristics from Science 5/13 for Stage 1 which would seem to fit this activity are:

1. ability to predict the effect of certain changes through observation of similar changes (Characteristic # 51, p. 41)

2. ability to find answers to simple problems by investigation (Characteristic # 55, p. 41)

3. awareness that more than one variable may be involved in a particular change (Characteristic # 57, p. 41)

It can be assumed that this activity is appropriate for a child at the Grade Two level.

This activity can be categorized as suitable.

12. ACTIVITY (p. 26)

The four pictures on the left side of this page show: a banana sliced on cereal, an orange cut in half to expose some seeds, a pear cut in half and a strawberry.

Have the children identify these fruits and then answer the questions.

*Which of these seeds do people eat?
*Which do they throw away?

Have the children name some other fruits and vegetables that could be put in these two categories.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity, the child needs only to have had the experience of eating oranges, pears, bananas and strawberries.

In order to recall other fruits and vegetables which would fit into these two categories, a child needs to have had experience eating or seeing other fruits and vegetables.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The developmental level required for a child to deal adequately with this activity would come from his everyday experiences with eating and seeing others eat. Based on their experiences there could be variations in answers for this particular activity. Some children may have been led to believe that apple seeds are not to be eaten while others will believe that they should be eaten because some very important food value comes from apple seeds.

Some characteristics from Science 5/13 which would seem to suggest that this activity is appropriate for a child at Stage 1 are:

1. ability to gropp things consistently according to chosen or given criteria (Characteristic #45, p. 41)
2. ability to group living and non-living things by observable attributes. (Characteristic #48, p. 41)
3. appreciation that things that are different may have features in common (Characteristic #50, p. 41)

The activity is appropriate for a child at the Grade Two level.

This activity can be categorized as suitable.

13. ACTIVITY (p. 27)

The pictures on the left side of this page show six fruits or pods that have been cut open. The three arrows point to different parts of the fruit or pod in each picture. However, in each case, only one arrow points to the seed. The children are asked to pick which arrow, "A", "B", or "C", points to the seed in each numbered drawing. Have the children identify the pictures and then choose the arrows that point to the seeds in each.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity the child is expected to be able to classify by naming the arrows which indicate seeds in each picture. Only one characteristic is involved in the classification performed.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974) children begin to classify around five or six years of age (Characteristic #26, p. 39). Since the child is required to classify by naming all the seeds in these pictures, one can assume that it will be possible for a child at the pre-operational stage of development to carry out this activity. The characteristics and specific function and location of seeds will have been known by the child at this stage because of the daily experiences he will have had up to this point.

The Science 5/13 Program gives as one of its characteristics for Stage 1, the ability to group living and non-living things by observable attributes (Characteristic #48, p. 41). This, too, would indicate that the child at Stage 1 (the pre-operational stage) would have very little difficulty in doing this activity.

This activity can be categorized as suitable.

14. ACTIVITY (p. 35)

For this activity each small group of children should be given: 1 apple or potato, 1 empty oatmeal box, 1 piece of cheesecloth, 1 eyedropper, 1 dull-edged knife, a magnifying glass, 10 mealworm larvae, 1 bottle colored nail polish, 100g oatmeal, 1 paper towel, 1 scissors, 5 toothpicks and some water.

Show the children how to cut out the center of the oatmeal lid. The cheesecloth should be placed between the lid and the top of the box.

Put about 10 mealworm larvae and 25g of oatmeal flakes into the box. Put a crumpled paper towel and a slice of apple or potato on top of the oatmeal. Moisten the towel by using an eyedropper. The towel will give the mealworms some dark crevices in which to hide, the oatmeal will be used as food, and the apple or potato slice will provide moisture and a change of diet. From time to time, put in a freshly crumpled towel, another apple slice, and some more oatmeal. The children will be able to observe the development of mealworms from larvae to adults.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity the child is expected to be able to observe the larvae as they develop into pupae and finally into adults. Children are expected merely to observe the changes as they occur.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Beard (1969), thinking remains to a considerable degree tied to the children's actions during the pre-operational stage (Characteristic #1, p. 36). The characteristics for Stage 1 in Science 5/13 indicate that children at this stage have a willingness to wait and to keep records in order to observe change in things (Characteristic #41, p. 40). One can assume, then, that the average child at the pre-operational stage of development will be able to handle this activity because the child is observing something concrete develop.

This activity can be categorized as suitable.

15. ACTIVITY (p. 36)

Let the children examine a mealworm larva with a magnifying glass. Ask them to describe what it looks like and how it moves.

Encourage the children to be curious and find out as much as they can. Have them agree on a description of a "larva".

INTELLECTUAL DEMANDS OF THE ACTIVITY

This activity requires that the child observe and then based on his own observation or perception, give a description of the larva.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Beard (1969), the thinking of the pre-operational child is dominated by his immediate perceptions (Characteristic #8, p. 37). Since the child is being asked to describe the larva in terms of his own perception of it, the activity is appropriate for a child at the pre-operational stage of development.

This activity can be categorized as suitable.

16. ACTIVITY (p. 41)

You might want to begin this lesson by having the class make a chart showing animals that they remember seeing last summer.

Example:

	Name	Where Found		Stage		Food	
		Summer	Winter	Summer	Winter	Summer	Winter
Birds	robin						
	pigeon						
Insects	housefly						
	honey bee						

Put the chart where it is readily available. You may want to have the children illustrate the chart. Keep the chart throughout the winter months. It can be a running account of what the children learn through observation, reading, and accounts from other people.

INTELLECTUAL DEMANDS OF THE ACTIVITY

This activity requires that the child record specific information as it becomes available. However, before the chart is made the child is expected to recall prior experiences with animals.

ANALYSIS ACCORDING TO PIAGET'S STAGES

Science 5/13 lists as some of the charcteristics for Stage 1:

1. awareness of changes which take place as time passes (Characteristic #42, p. 40)

2. ability to group living things by observable attributes (Characteristic #48, p. 41)

3. ability to use books for supplementing ideas or information (Characteristic #62, p. 42)

4. ability to tabulate information and use tables (Characteristic #65, p. 42)

5. awareness of seasonal changes in living things (Characteristic #68, p. 42)

Since a child is expected to possess these abilities at Stage 1 (Piaget's pre-operational stage), then it would follow that the activity of observing and recording information would be appropriate for a child at the pre-operational stage of development.

This activity can be categorized as suitable.

17. ACTIVITY (p. 42)

Cut open some galls so the children can see what is inside them. You also might want to put a whole gall in a cage. If you do, you will need: a litre-size milk carton and the leg from an old pair of pantyhose. Cut a large window in one side of the carton and draw the stocking over the whole carton. Stuff the open end of the stocking into the open end of the milk carton. Let the children observe the adult insects when they emerge.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In carrying out this activity children are simply expected to observe the insect parasites as they emerge from the gall.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The children will have something concrete to deal with in this activity so they can rely exclusively on their own perceptions. According to Beard (1969), the child at the pre-operational stage engages in operational thinking which is dominated by immediate perceptions (Characteristic #8, p. 37). This level of thinking is sufficient for carrying out this activity. Consequently, a child at the pre-operational stage would be able to deal adequately with the observation which is necessary in the activity.

This activity can be categorized as suitable.

18. ACTIVITY (p. 43)

If you live in an area where it snows during winter, take the class outdoors when there is snow on the ground. Have them locate possible hibernating places, such as under tree bark, under leaves, in the soil next to the sidewalk, in the soil next to the building, and under stones.

Have the children place thermometers in or under some of these places. Then have them check the thermometers after a while. What is the warmest place they can find? Have them compare the temperatures of these places to the outdoor air temperature. What is the difference in temperatures?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity the child is expected to read the thermometer in places which will have different temperatures. Then he will need to obtain the outdoor air temperature. Using this information he is to compare the temperatures by finding the differences. The whole activity is based on the child's ability to perceive, observe and then to compare by subtraction.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), when a child is in the concrete operations stage he is becoming more aware of the relations that exist between separate events (Characteristic #94, p. 45). In this activity the child is expected to see a relationship between the differences in temperatures and the particular locations of the hibernating places and the outdoor air.

These characteristics from Stage 2 of the Science 5/13 Program seem to suggest that the activity is appropriate for children at that stage rather than Stage 1:

1. knowledge of sources and simple properties of common forms of energy (Characteristic #115, p. 46)

2. appreciation that comparisons can be made by use of an intermediary (Characteristic #107, p. 46)

3. knowledge of ways to measure properties of non-living materials (Characteristic #116, p. 46)

It can be assumed that the child at the later concrete operations stage will be better able to deal with this particular activity than one who is in the pre-operational stage.

This activity can be categorized as unsuitable.

The analyses of the sample of activities for the unit on Living Things indicated that of the 18 activities analyzed, 14 were found to be suitable and 4 unsuitable. (Table 1).

TABLE 1

Summary of Findings for Unit on Living Things

Unit: Living Things		
Activity Number	Findings	
	Suitable	Unsuitable
1	X	
2	X	
3	X	
4	X	
5	X	
6		X
7	X	
8	X	
9		X
10		X
11	X	
12	X	
13	X	
14	X	
15	X	
16	X	
17	X	
18		X
Total	14	4

Analysis of Activities from Unit: SPACE

19. ACTIVITY (p. 48)

Have the children look at the bottom picture on page 48 where a boy is measuring the length of a newspaper with his pencil. Have three or four children use their own pencils to measure the same object (the top of the desk, for example). Make sure that all the children do not use new pencils; some of the pencils should be well used. Then ask: Why did you get different measurements? What would happen if all of us agreed to set aside one pencil and use only this to measure?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity a child must be able to use arbitrary units of measurements and should also understand that measurement is division into regular parts. That is, a child would need conservation of length.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), the necessary concepts of change of position, conservation, and an external reference system as a prelude to measure do not appear for many children until age seven or eight (Characteristic # 84, p. 44). This indicates that the average child in Grade Two would be able to manage the measuring involved in this activity.

This activity can be categorized as suitable.

20. ACTIVITY (p. 49)

Have students duplicate a particular shoe cutout. All should duplicate the same cutout. The original cutout should have "standard" written on it. Have the children use the "shoe" standard to measure some common items at home. Have the students draw pictures of the items measured, and record their "shoe" measurements. Have students share their information in class.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity with sufficient understanding, a child will need conservation of length, for he is being asked to measure an object.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to one of the characteristics of Stage 1 of the Science 5/13 Program, children at this stage will be ready for the development of concepts of conservation of length and substance (Characteristic # 53, p. 41). Since conservation of length typically occurs at this stage, it can be assumed that this activity will be appropriate for children operating at this stage.

This activity can be categorized as <u>suitable</u>.

21. ACTIVITY (p. 51)

Have the children look at page 50: (a scientist measuring an animal, a builder measuring the width of a door frame, and a tailor measuring the height of the hem of the dress). Say: Suppose you wanted to measure smaller things. For example, you might want to measure the length of a crayon on your desk. Then you might want to use a ruler shorter than a metre stick. Pass out centimetre rulers or have the class look at the rulers on pages 51 and 52. Centimetre rulers are commonly either 15 cm or 30 cm long. Demonstrate how to measure objectsusing either actual centimetre rulers or the centimetre ruler on page 52. One end of the object should be aligned with the "zero" end of the ruler. Then display a variety of small objects. Have the groups of children draw pictures of the objects on a chart like the one shown on the page. Then have the groups measure the length of the real objects and record their measurements on the chart.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity, children must be able to use centimetre rulers to measure small objects and then know how to tabulate these measurements on a chart. They must also have conservation of length.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), the necessary concepts of change of position, conservation, and an external reference system as a prelude to measurement do not appear for many children until age seven or eight (Characteristic # 84, p. 44). This indicates that the average child in Grade Two would be ready for the part of the activity which involves measuring.

One of the characteristics of Stage 1 of the Science 5/13 Program indicates that children at this level will have the ability to tabulate information and use tables (Characteristic # 65, p. 42). This suggests that the part of the activity involving tabulating measurements would be appropriate for the Grade Two child.

This activity can be categorized as suitable.

22. ACTIVITY (p. 52)

Have the children measure and record the length and width of their science book. Each child might record his or her measurements in centimetres on a large wall chart. Discuss with the children the extent of agreement and the accuracy of these measurements. Ask: Is the book wider than it is tall? What is the difference in centimetres?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity the child is expected to measure and record lengths and widths and then to find the differences in lengths and widths by subtraction. To carry out the measurements involved in this activity, a child would need conservation of length.

ANALYSIS ACCORDING TO PIAGET'S STAGES

With respect to the recording of measurements, it is possible for a child at the pre-operational stage to perform this part of the activity, as is indicated by one of the characteristics of Stage 1 of the Science 5/13 Program: ability to tabulate information and use tables (Characteristic # 65, p. 42).

Since subtraction is the inverse of addition and addition is a concept that children are able to learn at about 7 years of age (Copeland, 1974) (Characteristic # 25, p. 39), then children at the late pre-operational or early concrete operational stages should be ready for this part of the activity which involves subtraction.

According to one of the characteristics of Stage 1 of the Science 5/13 Program, children at this stage will be ready for the development of concepts of conservation of length and substance (Characteristic # 53, p. 41). Therefore, the part of the activity which involves measurement would be appropriate for children in Grade Two.

This activity can be categorized as suitable.

23. ACTIVITY (p. 54)

Page 55 shows: a piece of string is put around a tire, the string is cut and laid on the ground, and finally the length of the string is measured with a metre stick. Ask the children: what is being measured? Do you think the two measurements should be the same? Ask whether anyone can suggest a way to measure the length of the schoolyard using a bicycle.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity a child is expected to go from circular to linear measurement and should, therefore, have conservation of length and should be able to use arbitrary or standard units of measurement as appropriate.

In order to suggest ways to measure the length of the schoolyard using a bicycle, the child must also be able to see the relationship which exists between the measuring of the tire and the length of the schoolyard in terms of the length of the tire.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), measurement in its operational form (i.e. with immediate insight rather than by trial and error) is not achieved until eight or eight and one-half years of age (Characteristic #86, p. 44). This would indicate that this activity, which involves moving from circular to linear measurement, would not be suitable for a child until he has reached the concrete operational stage. In relation to measurement, the Science5/13 Program lists as characteristics of Stage 2 (the late concrete operations stage) the following: (1) appreciation of measurement as division into regular parts and repeated comparisons with a unit (Characteristic # 106, p. 46), (2) ability to choose and use either arbitrary or standard units of measurements as appropriate, (Characteristic # 113, p. 46), and (3) appreciation of the relationships of parts and wholes (Characteristic # 125, p. 47). This, too, suggests that this particular activity can be dealt with more adequately by the child at the late concrete operations stage.

This activity can be categorized as unsuitable.

24. ACTIVITY (p. [illegible])

Have the children estimate how many bike wheel turns it will take to cover a certain distance. They can check their estimates by putting a piece of tape on the bicycle tire, then wheeling the bicycle the particular distance. Count the number of times the tape touches the ground. This tells the number of turns made by the tire.

INTELLECTUAL DEMANDS OF THE ACTIVITY

This activity involves making estimates and then comparing or checking, through investigation, the estimate with the actual distance. The concept of conservation of length is inherent in this activity.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), measurement in its operational form (i.e. with immediate insight rather than by trial and error) is not achieved until eight or eight and one-half years of age (Characteristic # 86, p. 44). This would indicate that this activity, which involves moving from circular to linear measurement, would not be suitable for a child until he has reached the concrete operational stage. In relation to measurement, the Science 5/13 Program lists as characteristics of Stage 2 (the late concrete operations stage) the following: (1) appreciation of measurement as division into regular parts and repeated comparisons with a unit (Characteristic # 106, p. 46), (2) ability to choose and use either arbitrary or standard units of measurements as appropriate, (Characteristic # 113, p. 46), and (3) appreciation of the relationships of parts and wholes (Characteristics # 125, p. 47). This, too, suggests that this particular activity can be dealt with more adequately by the child at the late concrete operations stage.

This activity can be categorized as unsuitable.

25. ACTIVITY (p. 55)

Ask the children to use some empty cans (from juice, fruit, or vegetables) to measure distance, such as the width and length of their desks. Have them mark the lip of each can and roll it one turn. They should measure the distance of each turn in centimetres.

INTELLECTUAL DEMANDS OF THE ACTIVITY

Involved in this activity is conservation of length of a complicated fashion - going from circular to linear. This activity also involves addition skills because the student is expected to add the distances rolled in each turn to obtain the total distance.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), measurement in its operational form (i.e. with immediate insight rather than by trial and error) is not achieved until eight or eight and one-half years of age (Characteristic # 86, p. 44). This would indicate that this activity, which involves moving from circular to linear measurement, would not be suitable for a child until he has reached the concrete operational stage. In relation to measurement, the Science 5/13 Program lists as characteristics of Stage 2 (the late concrete operations stage) the following: (1) appreciation of measurement as division into regular parts and repeated comparisons with a unit (Characteristic # 106, p. 46), (2) ability to choose and use either arbitrary or standard units of measurements as appropriate, (Characteristic # 113, p. 46), and (3) appreciation of the relationships of parts and wholes (Characteristic # 125, p. 47). This, too, suggests that this particular activity can be dealt with more adequately by the child at the late concrete operations stage.

This activity can be categorized as unsuitable.

26. ACTIVITY (p. 56)

For this activity you will need: buttons, life savers, bottle caps, paper clips, other small objects, and centimetre ruler.

Ask the students to estimate which objects will be about 1 cm. wide or long. After they make their estimates, have them measure objects in the top photo on page 59 as well as the objects you have brought to class.

INTELLECTUAL DEMANDS OF THE ACTIVITY

This activity involves making estimates and then measuring the objects to find their actual lengths.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Beard (1969), children in the concrete operations stage begin to use some Euclidean concepts: measures of length, area and angles can be applied intelligently (Characteristic # 76, p. 43).

One of the characteristics of Stage 1 of the Science 5/13 Program which would seem to fit this activity is: enjoyment in comparing measurements with estimates (Characteristic # 40, p. 40).

The comparing of measurements with estimates which is involved in this activity is appropriate for a child at the pre-operational, early concrete operations/Stage 1.

This activity can be categorized as suitable

The analyses of the sample of activities for the unit on Space indicated that of the 8 activities analyzed, 5 were found to be suitable and 3 unsuitable.

Table 2 shows these results.

TABLE 2

Summary of Findings for Unit on Space

Unit: Space		
Activity Number	Findings	
	Suitable	Unsuitable
19	X	
20	X	
21	X	
22	X	
23		X
24		X
25		X
26	X	
Total	5	3

Analysis of Activities from Unit: TIME

27. ACTIVITY (p. 59)

Direct the children's attention to filmstrip 1 (a dripping faucet). Ask: (1) Is there anything in the pictures that tells you how long it takes for each drip to happen? (2) Has anyone seen or heard a faucet dripping? (3) Did it take a short time or a long time between drips?

Now have the children look at filmstrip 2 (a child eating). Ask: (1) What in the pictures tells you how long a time it is between the child's meals? (2) What unit of time does a clock measure? (3) How many hours have passed between the first picture and the fourth picture? (4) How many hours in a day? (5) How many days have gone by?

Have the children look at filmstrip 3 (birthday cakes with increasing numbers of candles on them). Ask: (1) How long a time between each picture? (2) How do you know?

Then ask of the three filmstrips: (1) Which events take only a short time? (2) Which take longer?

Finally, explain that all these events are regular because they occur in a repeating pattern.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity a child must have some concept of "short time" and "long time"; some concept of the length of an hour and a day; and some concept of the length of a year. In order to sequence the time spans from shortest to longest it would be necessary for a child to know how to sequence.

ANALYSIS ACCORDING TO PIAGET'S STAGES

Copeland says that at the concrete operational stage of development children begin to use words that express mathematical relations such as "more" or "less", "taller" or "shorter", "heavier" or "lighter" (Characteristic #93, p. 45). Therefore, the first part of the activity can be dealt with by children at the early concrete operational stage of development.

According to Copeland (1974), some children will have an understanding of time at eight to nine years of age (Characteristic # 92, p. 44). Therefore, it is reasonable to assume that a child at the early concrete operational stage should be able to work through the part of the activity which requires some concept of the length of an hour, a day, and a year.

The ability to seriate or order, such as from smallest to largest, with true understanding of the inclusion relations involved, develops usually at seven to eight years of age (Copeland, 1974) (Characteristic # 91, p. 44). A child at the early concrete operations stage would be able to do the part of the activity which requires that he indicate the event which takes the shortest time and the one that takes the longest time.

This activity can be categorized as suitable.

28. ACTIVITY (p. 60)

Call on children to tap out or act out the repetitive pattern of the events pictured on page 60 (a child swinging, a man rocking, a police car with siren, a clock ticking, people clapping, a dog barking). Which events are regular? Which are not? Have them support their identification of the events as regular or irregular in terms of a rule; "If the sounds or steps in an event are equally spaced, the event is a regularly occurring one".

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity a child must be able to recognize regularity in patterns after the terms "regular" and "irregular" are explained by means of the given rule.

ANALYSIS ACCORDING TO PIAGET'S STAGES

One of the characteristics of Stage 1 of the Science 5/13 Program is: recognition of regularity in patterns (Characteristic # 44, p. 41). Since it is expected that a child at the pre-operational stage will be able to recognize regularity in patterns, then this activity should be suitable for a child at the pre-operational stage.

This activity can be categorized as suitable.

29. ACTIVITY (p. 62)

Call on groups of children to use the room clock to time the activities on page 62. You will need some rubber balls, some jump ropes, some cups, and water. Ask the children to find out how many times they can do these activities in one minute.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity a child must be able to determine a minute by using a clock. He must watch the clock while at the same time watching the particular activity that is going on, whether it be drinking a glass of water or bouncing a ball.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), while the adult realizes that instruments used to tell time can move at different speeds to measure the same time, the pre-operational child cannot and most children will not until nine to ten years of age (Characteristic #88, p. 44). This would mean that until a child reaches these ages he may have difficulties with timing these events using a clock. Consequently, it can be assumed that a child would not be ready for this activity until the late concrete operational stage, which would be approximately the Grade Five level for most children.

This activity can be categorized as unsuitable.

30. ACTIVITY (p. 65)

Have the children set up model pendulums as shown on page 65 (using a metal nut and a string and a book to hold the string). Attach a small object to one end of a 90 cm length string inside a book, leaving 50 cm to hang. When the book is placed on a desk with one side extending over the edge, the pendulum will swing free.

Each group will need a timer, and a person to start the pendulum swinging. Have a child in each group start the pendulum. Using the clock with a second hand, have the rest of the group count the number of swings in 10 seconds. Remind the class that a swing is one complete back-and-forth motion.

Now tell each group to shorten the string on their pendulum by pulling the string back through the book. How many swings does it make in 10 seconds?

Finally, have the children lengthen the string to about 70 cm. How many swings does the pendulum make in 10 seconds?

INTELLECTUAL DEMANDS OF THE ACTIVITY

For this activity there may be a need to control variables, such as rate of walking around the room and particular paths chosen. The child will also need to be quite capable with measurements in order to vary the length of the strings to make the activity more meaningful.

ANALYSIS ACCORDING TO PIAGET'S STAGES

Since there may be a need to control certain variables for this activity, it may not be possible to make the activity meaningful in this respect until late concrete operations stage or early formal operations stage. Science 5/13 gives as one of the characteristics of Stage 3 of the program the ability to separate, exclude or combine variables in approaching problems (Characteristic # 143, p. 49). This would indicate that there might be potentially serious difficulty inherent in this activity until that stage is reached.

In terms of measurement, Copeland (1974) says that the ability to measure in its operational form (with immediate insight rather than by trial and error) is not achieved until eight or eight and one-half years of age (Characteristic # 86, p. 44). This part of the activity would be suitable for a child at the concrete operations stage.

In conclusion, this activity would be more suitable for a child at the late concrete or early formal operations stages, and, therefore, too difficult for the Grade Two child.

This activity can be categorized as unsuitable.

31. ACTIVITY (p. 67)

Invite the children to vary the string length of their pendulums. Using the sweep hand of a clock as timer, have them count the number of complete swings made during 10-second intervals at each length.

INTELLECTUAL DEMANDS OF THE ACTIVITY

For this activity there may be a need to control variables, such as rate of walking around the room and particular paths chosen. Control of variables requires quite advanced formal thought according to Piaget's stages of development.

ANALYSIS ACCORDING TO PIAGET'S STAGES

There may be a need to control certain variables for this activity. Consequently, it may not be possible to make the activity meaningful for students at the pre-operational level. One of the characteristics of Stage 2 of Science 5/13 is: ability to investigate variables and to discover effective ones (Characteristic # 111, p. 46). Not until Stage 3 (formal operations) does the child have the ability to separate, exclude or combine variables in approaching problems (Characteristic # 143, p. 49). There is potentially serious difficulty inherent in this activity for the child at the pre-operational stage.

This activity can be categorized as unsuitable.

32. ACTIVITY (p. 63)

Set up two one-hour activities. One activity could be a reading or math lesson. The other activity should be one the children really enjoy. (Perhaps you could get permission to let them expand their noon play time to an hour.) Time both activities with an alarm clock or an hour automatic timer. Let the children see the time before and after each activity. Then ask:

1. Does time pass more quickly or slowly or does it just seem that way?

2. Can one hour really be longer or shorter than another hour?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity the child is expected to coordinate duration of time with order of events, in order to determine whether time passes more quickly or more slowly for different events and to determine whether one hour can be of different lengths.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), it is not until eight and one-half to nine years that children are able to coordinate durations of time with the order of events (Characteristic #28, p. 39). It can be assumed that this activity would be more suitable for the child at the concrete operational stage of development. Also, Copeland (1974) says that some children will have an understanding of time at eight to nine years of age. Others will not be ready for true understanding of time at ten years of age (Characteristic #92, p. 44).

This activity can be categorized as unsuitable.

33. ACTIVITY (p. 69)

Encourage children to find newspaper and magazine pictures of events that can be timed in hours. Have them display their pictures on a bulletin board.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity in a meaningful way, a child must have some concept of what an hour is.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The collecting of pictures gives children an opportunity to work with the concrete and this part of the activity should hold interest for the child at the pre-operational level.

However, for children to even estimate the length of time it takes for a particular event, it is necessary that they have some concept of duration of time. According to Copeland (1974), it is not until eight and one-half to nine years that they are able to coordinate durations with the order of events (Characteristic #28, p. 39). Copeland (1974) says that telling time requires an intellectual construction not usually found in children until nine or ten years of age (Characteristic #87, p. 44). Consequently, this activity would be more suitable for a child at the mid to late concrete operational stage of development and, therefore, not suitable for Grade 2.

This activity can be categorized as unsuitable.

34. ACTIVITY (p. 76)

Ask the children to make their own clocks. They will need: paper plates, pencils, two colors of oaktag for hands, brass fasteners, scissors, and crayons.

Show the children a model clock face that you have made, and demonstrate how they can make one. Cut hands from colored oaktag, using one color for the minute and hour hands, the other for the second hand. (Make a few patterns and have the children trace them.) Pierce the center of the plate and one end of each hand with the sharp end of a pencil. Attach the hands to the plate with a brass fastener so they rotate separately.

Have the children mark the hour numerals on the clock face, using the diagram on page 76 as a model.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity, a child must be able to follow oral directions in making a model of a clock.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to one of the characteristics of Stage 1 in Science 5/13 children at this stage will be able to record impressions by making models, painting or drawing (Characteristic # 66, p. 42). The ability to make models is essential for working through this activity. Therefore, a child at the pre-operational stage (Stage 1) will be ready to deal adequately with this particular activity.

This activity can be categorized as suitable.

35. ACTIVITY (p. 77)

Have the children make some flash cards for telling time. They will need: index cards and marking pens.

Have some children draw a clock face on each card. Each face should show a different time. The cards can be used for time-telling games.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity, a child must be able to make models of clocks, indicate different times using the short and long hands.

ANALYSIS ACCORDING TO PIAGET'S STAGES

One of the characteristics of Stage 1 in the Science 5/13 Program is the ability to record impressions by making models, painting or drawing (Characteristic # 66, p. 42). Therefore, the mechanics involved in this particular activity would not be too difficult for the child at the pre-operational stage. Meaningful indications of different times, however, would be more easily handled by a child at the concrete operational stage because according to Copeland (1974), telling time requires an intellectual construction not usually found in children until nine or ten years of age (Characteristic # 87, p. 44). Therefore, it can be assumed that this activity would be more suitable for a child at the later concrete operations stage.

This activity can be categorized as unsuitable.

36. ACTIVITY (p. 78)

On a piece of paper, have the children draw arcs, or shade in pie sections, that show how far the hour hand and the minute hand have moved for each pair of clock faces. Call on some children to draw these on the chalkboard as a check for the others. What are some activities that take place at the times indicated? What activities do the children know that take place during the time intervals shown?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity, a child must be able to identify the shapes of the sections which would be indicated by the positions of the hands. They also must be familiar enough with time intervals to be able to suggest activities which would habitually occur at those specific times.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Beard (1969), children at the pre-operational stage have the ability to represent one thing by another (Characteristic # 1, p. 36). At the concrete operations stage Beard (1969) writes, children begin to use some Euclidean concepts such as measures of angles, which can; at this stage be applied intelligently (Characteristic # 76, p. 43). The part of the activity which involves drawing the arcs and shading in pie sections can be done by children at the early concrete operational stage.

According to Copeland (1974), some children will have an understanding of time at eight to nine years of age. Others will not be ready for true understanding of time at ten years of age (Characteristic # 92, p. 44). The part of the activity which involves time intervals will be beyond the capabilities of the pre-operational, early concrete operations child.

This activity can be categorized as unsuitable.

The analyses of the sample of activities for the unit on Time indicated that of the 10 activities analyzed, 3 were found to be suitable and 7 unsuitable.

Table 3 shows these results.

TABLE 3

Summary of Findings for Unit on Time

Unit: Time		
Activity Number	Findings	
	Suitable	Unsuitable
27	X	
28	X	
29		X
30		X
31		X
32		X
33		X
34	X	
35		X
36		X
Total	3	7

Analysis of Activities from Unit: ENERGY

37. ACTIVITY (p. 83)

Have the children make simple water wheels that will turn under a faucet. Let them design and create their own, using such things as corks, cans, milk cartons, paper or plastic cups, pieces of aluminum pans, rubber bands, nails and thumbtacks.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do what is involved in this activity, the child is expected to be capable of inferring the link between energy and motion.

ANALYSIS ACCORDING TO PIAGET'S STAGES

One of the characteristics of Stage 1 in the Science 5/13 Program states that children at this stage will have a recognition of the action of force (Characteristic # 47, p. 41). If a child at this stage can recognize that force can cause action, then he should be capable of dealing appropriately with this activity.

This activity can be categorized as suitable.

38. ACTIVITY (p. 86)

Take the children for a walk to look for work being done. When someone identifies a situation in which work is being done, ask:
(1) Who or what is doing the work?
(2) How can you tell that work is being done?
(3) Where does the energy come from?
(4) Is this work useful?

INTELLECTUAL DEMANDS OF THE ACTIVITY

This activity expects the child to relate two abstract concepts - work and energy.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), children operating at the formal operations stage will be at the abstract level in their thinking (Characteristic #135, p. 48). This suggests that a child at this level will be ready for the reasoning and understanding involved in establishing a link between work and energy.

In this particular activity, even though energy is expended, no work (in the physical sense) is done. This becomes very misleading.

This activity can be categorized as unsuitable.

39. ACTIVITY (p. 89)

You may wish to bring in and demonstrate a "jet-propelled" balloon, a wind-up clock, and a battery-operated toy. The children could try operating these things. They can bring in and show still other devices which store energy.

INTELLECTUAL DEMANDS OF THE ACTIVITY

The concept of stored energy is an abstract one which the child must understand on a very basic level in order to carry out this activity with sufficient understanding of which devices have stored energy. The first part of the activity involves observing certain devices operating.

ANALYSIS ACCORDING TO PIAGET'S STAGES

One of the characteristics of Stage 1 in the Science 5/13 Program states that children at this stage will have an appreciation that ability to move or cause movement requires energy (Characteristic # 61, p. 41).

This suggests that this particular activity is appropriate for a child at the Grade Two level.

This activity can be categorized as suitable.

40. ACTIVITY (p. 90)

Each small group should have: one wind-up toy car, one box of crayons, one paper chart, and one metric ruler. Have the children measure the distance traveled by their car each time. They may use metre sticks or metric tape measures. The distances can be stated simply in metres (e.g., 5 m) or in centimetres (e.g., 543 cm).

Each child in the group should have a responsibility: to turn the key, to count the turns, to measure the distance moved, to record the distance, etc.

Let the children do this activity at first just for fun, and later to compare records of each trial run.

Have the children predict how far the car will go after its spring has been given a certain number of turns, and then check their predictions. Ask: (1) How can you tell how much energy is stored? (2) How can you predict how far the car will move?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity, a child is expected to be able to measure the distances the car travels in either metres or centimetres while being aware of the number of turns it takes for a particular distance. He needs conservation of length. Then he must be able to compare the records of the trial runs.

Based on their records they are to predict how far the car will go with a certain number of turns. Finally, he is to answer questions about what he has learned through these observations.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), the ability to measure in its operational form (with immediate insight rather than by trial and error) is achieved by eight or eight and one-half years of age (Characteristic # 86, p. 44). The part of the activity which involves measuring can be handled by a child at the concrete operations stage.

According to one of the characteristics of Stage 1 of the Science 5/13 Program, children at this stage will be ready for the development of the concept of conservation of length (Characteristic # 53, p. 41).

This activity can be categorized as suitable.

41. ACTIVITY (p. 92)

Have the children draw a spiral on stiff paper, cut it out, and hang it on a thread above a heat source. Then have the children compare the motion of the pinwheel and/or spiral with that of the candle chimes. Ask the children: How does heat make these things move?

INTELLECTUAL DEMANDS OF THE ACTIVITY

To do this activity the child is expected to make a spiral following the instructions given. Then he is to compare the motions of the spiral, pinwheel and candle chimes and relate heat to motion.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The child at Stage 2 of the Science 5/13 Program is able to make models as a means of recording observations (Characteristic # 121, p. 46). Therefore, the construction of the spiral can be done by a child at that level.

Through simple observation a child at this stage will be able to compare the motions.

According to one of the characteristics of Stage 2 in the Science 5/13 Program, a child at this stage will be able to determine how the heat makes things move because it states that children at this stage will have knowledge of the sources and simple properties of common forms of energy (Characteristic # 115, p. 46).

In conclusion, this activity appears to be more appropriate for a child operating at Stage 2 of the Science 5/13 Program (i.e., late concrete operations stage).

This activity can be categorized as unsuitable.

42. ACTIVITY (p. 93)

Have the children pop some popcorn. Explain to them that in the kernels there are tiny pockets of water which are turned into steam. The steam expands and bursts the kernels open. This is what makes the kernels move about.

Try to get the children to relate this idea to steam engines.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In this activity the children are expected to observe the popcorn popping and then to infer from this observation how the steam engine works. They must relate heat to energy to motion.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Beard (1969), the child at the concrete operations stage is said to be operational in his thinking. The necessary logical thought is based in part on the physical manipulation of objects (Characteristic #81, p. 43). Copeland (1974) writes that the child at this level is becoming more aware of the relations that exist between separate events (Characteristic #94, p. 45). This suggests that a child at the concrete operations stage will be capable of dealing with this activity which involves making inferences based on observation.

Relating heat to energy to motion, however, involves some very complex relations and the reasoning involved would be on an abstract level.

According to Copeland (1974), children operating at the formal operations stage will be at the abstract level in their thinking (Characteristic #135, p. 48). The reasoning involved in relating heat to energy to motion would be more appropriate for children at the formal operations stage.

This activity can be categorized as unsuitable.

43) ACTIVITY (p. 94)

Each small group of children will need: one eye-dropper, one squeeze bottle of food coloring, a hot plate for the whole class, a cooking pan for the whole class, one plastic straw per group, four clear plastic tumblers per group, and some water.

There are two parts to this activity - one in which water is moved by stirring, and the other in which it is moved by heating.

In addition, in each part a comparable sample of water has nothing done with it. These pairs of situations - alike in all ways except one - make fair comparisons possible.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity, the child is expected to relate motion caused by pushing directly on a substance to motion caused by heating. In both cases, the concept is to be developed that heat may cause pushes, and thus make things move.

ANALYSIS ACCORDING TO PIAGET'S STAGES

In this activity children get to work at the concrete level in the sense that there is something available for them to see and manipulate. According to Copeland (1974), children at the concrete operational stage are not ready to work at the abstract level but are very much a part of the physical world (Characteristic # 95, p. 45). Copeland (1974) also writes that at the concrete operational stage the child is becoming more aware of the relations that exist between separate events (Characteristic # 94, p. 45). In this particular activity the events would be the moving of the water through stirring and the moving of the water through heating.

The Science 5/13 characteristic which would seem to fit this activity appears in the list for Stage 2: Knowledge of sources and simple properties of common forms of energy (Characteristic # 115, p. 46).

It can be assumed that this activity would be suitable for children at the late concrete operational stage of development (or Stage 2 of the Science 5/13 Program).

This activity can be categorized as <u>unsuitable</u>.

44. ACTIVITY (p. 95)

Have the children watch the liquid move inside an ordinary thermometer. Place the thermometer in a warm or cool place, or in warm water or ice water. Ask the children how a thermometer works. They might also observe the movement of the pointer of a dial-type thermometer if one is available. Both kinds of thermometers depend on heat causing things to move.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity the child is expected to read the thermometer in a cool place and a warm place and note the differences in temperatures. Using that information, he is to infer how a thermometer works. The whole activity is based on the child's ability to perceive, observe and infer a cause and effect relationship.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974) a child in the concrete operations stage is becoming more aware of the relations that exist between separate events (Characteristic # 94, p. 45).

The characteristic which would seem to fit this activity in the Science 5/13 Program appears in the list for Stage 1:

1. Awareness of cause - effect relationships
(Characteristic # 67, p. 42)

It can be assumed that the child at the Grade Two level will be capable of handling this activity.

This activity can be categorized as suitable.

45. ACTIVITY (p. 96)

Have the children draw pictures or make up stories to illustrate their ideas of how we get energy from the sun.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity, a child must have some concept of energy and how energy from the sun makes plants grow and how plants are eaten by people.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), the child is becoming more aware of the relations that exist between separate events, at the concrete operations level (Characteristic # 94, p. 45).

One of the characteristics of Stage 2 in the Science 5/13 Program states that a child at this stage will have knowledge of sources and simple properties of common forms of energy (Characteristic # 115, p. 46).

One can assume, then, that this activity is appropriate for a child who is operating at the late concrete operations stage or Stage 2 of the Science 5/13 Program.

This activity can be categorized as unsuitable.

46. ACTIVITY (p. 97)

Build a small fire of branches and twigs outdoors. Surround it with rocks or build it inside a large can. Have the children roast some marshmallows or pop some popcorn over the fire. Have them observe what is happening. Ask: (1) What makes the marshmallows cook (or the popcorn move)? (2) Where does the heat come from? (3) Where does the wood get its energy?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In this activity the child is expected to trace the energy link from the sun, to a piece of wood, to the heat the wood produces when it is burned.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to one of the objectives in Stage 1 of the Science 5/13 Program, a child at this stage should be ready for part of this activity. The objective states that at this stage there should be an awareness of sources of heat, light and electricity (Characteristic #60, p. 41). This suggests that the part of the activity which involves determining where the heat comes from would be appropriate for a child at Stage 1.

The chain of inference involved in this activity requires formal thought and according to one of the objectives for Stage 3 of the Science 5/13 Program, children at this stage of development will have the ability to use analogies to explain scientific ideas and theories (Characteristic #156, p. 49).

According to Copeland (1974), children operating at the formal operations stage will be ready for abstract thinking (Characteristic #135, p. 48).

Since this level of thinking and reasoning is essential for this activity, it can be assumed that the activity is more appropriate for a child at the formal operations stage.

This activity can be categorized as unsuitable.

47. ACTIVITY (p. 98)

This activity is to be done by small groups of children. Each group will need: 2 books, 1 can opener, 3 large coffee cans, 1 jar of black paint, 1 paint brush, 1 piece of construction paper, 1 jar of glue, 1 straight pin, 1 pair of scissors, 1 roll of masking tape, and 1 piece of thin wire (20 cm). Have the children read the text and look at the steps of this activity on pages 98-99. Go through the steps together... (1) Get 3 painted cans, all alike. (2) Cut out the bottoms of the cans. (3) Tape the cans together end to end. (4) Stand the cans on two books in the sunshine. (5) Get a piece of thin wire (such as twist wire for a plastic bag). (6) Tape a pin to one end of the wire. (7) Tape the wire to the top of the can.

To make the pinwheel, fold alternating corners to the center of the paper, as shown on page 99. It may be helpful to make a slight dent at the center of the pinwheel with a pencil point. This will keep the pinwheel from slipping off the pin point.

Allow the children time to watch their sun motors work. After they have had some time to do this, ask: (1) How could you make this motor turn on a cloudy day? Let the children test their ideas, and perhaps even have a contest to see which ideas are best.

INTELLECTUAL DEMANDS OF THE ACTIVITY

To do this activity the child is expected to make a model of a sun motor by following the instructions available to him and the teacher's guidance. Then after he sees how his model works, he is expected to be able to infer how it could work under different weather conditions.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The construction of the model would not be too difficult for the child at the concrete operational stage. One of the characteristics in Stage 2 of the Science 5/13 Program seems to suggest that this is so is: skill in devising and constructing simple apparatus (Characteristic # 117, p. 46).

According to Copeland (1974), the child at the concrete operational stage is becoming more aware of the relations that exist between separate events (Characteristic # 94, p. 45). Therefore, it can be assumed that a child at this stage will be able to see the relationship that exists between the sun motor and the sun and may also be able to make inferences about what one would need on a cloudy day to give the same result.

However, some of the characteristics in Stage 3 (formal operations) of the Science 5/13 Program which might suggest that the child is more ready for making inferences at the formal operations stage are: (1) ability to separate, exclude or combine variables in approaching problems (Characteristic # 143, p. 49) (2) ability to formulate hypotheses not dependent upon direct observation (Characteristic # 144, p. 49).

This activity can be categorized as <u>unsuitable</u>.

48. ACTIVITY (p. 99)

Have the children draw pictures that show how energy from the sun is used. These might depict trees or other plants growing, people or animals eating plants, wood being burned, water being evaporated from a puddle or lake in sunshine, etc. Some children might show recently developed ways of using energy from the sun directly, as in solar-heated houses.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity, a child must have acquired some concept of what energy is, and what energy from the sun can do. In this activity the child will need to take an abstract concept and then draw pictures representing how the energy is used.

ANALYSIS ACCORDING TO PIAGET'S STAGES

One of the characteristics of Stage 1 in the Science 5/13 Program states that children at this stage will have an awareness of sources of heat, electricity and light (Characteristic # 60, p. 41). Since this activity involves the sun as a source of heat and light, then it should be possible for a child at Stage 1 to handle this aspect of the activity.

The part of the activity which involves drawing pictures should be suitable for children at Stage 1. A characteristic for Stage 1 in the Science 5/13 Program which is an indication of this ability is: ability to record impressions by making models, painting or drawing (Characteristic #,66, p. 42).

In conclusion, this activity is appropriate for children at Stage 1.

This activity can be categorized as suitable.

The analyses of the sample of activities for the unit on Energy indicated that of the 12 activities analyzed, 5 were found to be suitable and 7 unsuitable.

Table 4 shows these results.

TABLE 4

Summary of Findings for Unit on Energy

Unit: Energy		
Activity Number	Findings	
	Suitable	Unsuitable
37	X	
38		X
39	X	
40	X	
41		X
42		X
43		X
44	X	
45		X
46		X
47		X
48	X	
Total	5	7

Analysis of Activities from Unit: MATTER

49. ACTIVITY (p. 106)

For this activity you will need: a large table divided into three sections with masking tape; an assortment of objects that include solids, liquids and gases; three pieces of paper; and some crayons. Label one piece of paper "SOLIDS", another "LIQUIDS", and a third "GASES". Put each piece of paper on one section of the table.

Have each child select an object from the classroom and bring it to the table. Let the children place their objects in the correct section.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order for a child to do this activity, he will need to have established the concept of solids, liquids and gases and be able to classify objects as being solids, or containing liquids or gases.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), at around age five or six children make classifications by shape or color or both (Characteristic # 26, p. 39). This suggests that the classifying to be done in this activity can be handled by a child at the pre-operational stage of development.

According to Beard (1969), the concrete operations stage marks the beginning of logico-mathematical thought. The necessary logical thought is based in part on the physical manipulation of objects (Characteristic # 81, p. 43). This indicates that children at this level (the early concrete operations stage) will be ready to work with the classification of solids, liquids and gases on this level because they will be dealing with concrete examples of solids, liquids and gases.

This activity can be categorized as suitable.

50. ACTIVITY (p. 107)

Once the children are familiar with the process of a liquid changing to a gas, hold a plate over the steam that is escaping from a kettle. Ask the children to look carefully at the plate. They should see tiny droplets forming on the plate. Explain that they are seeing condensation. Have a pan nearby to catch the water as it falls off the plate. Ask the children: (1) Does this liquid change to a gas? How? (2) Does this gas change to a liquid? How?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity the children are expected to observe the teacher's demonstration and then, based on this observation, to tell whether or not the liquid can change into a gas and whether the gas can change into a liquid. Even though they can observe the changes which are taking place, they will need to have some concept of what a liquid is and what a gas is, and to understand the reversibility involved.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The changing of gases to liquids and liquids to gases is an abstract idea even though the children are to be shown the process of condensation. In effect, the child has to understand, without direct evidence, that the substance is still there even when it can no longer be seen. According to Copeland (1974), a child at the formal operations stage can reason or hypothesize with ideas and he is at the abstract level of thinking (Characteristics # 130 and 135, pp. 47, 48). It can be assumed, therefore, that this activity would not be appropriate for children in Grade Two because they would be operating at the pre-operational stage or at best the early concrete operational stage (i.e., the average Grade Two child).

This activity can be categorized as unsuitable.

51. ACTIVITY (p. 114)

Crush a piece of pencil lead and sprinkle some lead dust over a piece of white paper and in a beam of sunlight (or examine the contents of a pencil sharpener). Children could try erasing the line drawn on the white paper with an eraser and then observe black lead bits on the eraser with a magnifying glass. (Pencil lead is made of graphite, clay, and other binders.)

INTELLECTUAL DEMANDS OF THE ACTIVITY

By observing the pencil lead being crushed and then by looking at the eraser after it has been used to erase a black line the child is expected to see that the lead is made up of very small bits. Also, the child must be able to use the magnifying glass.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The Science 5/13 Program, in one of its characteristics for Stage 1, suggests that children at this stage will have the ability to find answers to simple problems by investigation (Characteristic # 39, p. 40). This indicates that a child at this stage would, especially after using the magnifying glass, be able to understand that the lead is made up of particles.

This activity can be categorized as suitable.

52. ACTIVITY (p. 116)

Have the children fold a paper towel into a funnel, as shown on page 116. While one child holds the towel in place, have another pour the sugar solution through it. Do the children think the filtered water will taste sweet? Why? Have the children taste it and report their findings to the class. How do the children think the sugar got through the towel? Have them examine the paper towel again with a magnifying glass, and discuss the idea that sugar must be composed of bits too small to be seen. Can the children think of a way to make the sugar in the water visible again?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In this activity the child is expected to predict whether or not the water will taste sweet and explain why. Then he must check his prediction by tasting it. Without really seeing how the sugar got through the towel, the child is expected to be able to explain how it happened. Finally, the child will need to explain how the sugar in the water can be made visible again.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The child must be at a very abstract level of reasoning in order to understand that the substance is still there, unchanged except in phase. The level of abstraction increases when the child is expected to tell how to make the sugar visible again. According to Copeland (1974), a child at the formal operations stage is at the abstract level and he can use the procedures of the logician or scientist (a hypothetic-deductive procedure) that no longer ties his thoughts to existing reality (Characteristics #132 and 135, p. 48).

It can be assumed that this activity would be beyond the stage of development of the Grade Two child.

This activity can be categorized as unsuitable.

53. ACTIVITY (p. 116)

For this activity each small group of children will need: 1 glass plate or square, 1 magnifying glass, 1 piece of black construction paper, 1 spoon, 1 spoonful of granulated sugar, 1 clear plastic tumbler, and some water.

Distribute some of the sugared water to small groups of children for observation. Have each group place a few drops on a glass plate with black paper underneath it. Have the children move their samples into the sunlight or into a warm place in the room. Let them check the slide every half hour or so until the water has dried up. Then have them examine the slide under a magnifying glass.

(1) What do they see?

(2) How can they tell if the white grains are sugar?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity the child is expected to observe the few drops of water evaporating and then use a magnifying glass to check what is left on the slide after the evaporation has taken place. Then the child must figure out a way to test whether or not the white grains left on the slide are sugar.

ANALYSIS ACCORDING TO PIAGET'S STAGES

Two of the characteristics for Stage 1 of the Science 5/13 Program which suggest that the investigation involved in this activity can be handled by children at that stage are:

1. awareness that there are various ways of testing out ideas and making observations (Characteristic # 38, p. 40)

2. ability to find answers to simple problems by investigation (Characteristic # 39, p. 40).

This activity can be categorized as suitable.

54. ACTIVITY (p. 118)

Each small group will need: 1 strong-smelling liquid, 1 small jar, 1 paper towel, and 1 rubber band.

Give each group a different strong-smelling liquid in a jar. Use such substances as shaving lotion, perfumes, vanilla or peppermint extract, etc. The jars can be exchanged among the groups, so that each group has several substances to investigate.

Have each group cover the top of the jar with a paper towel and fasten it tightly with a rubber band. The jar may then be taken into another room and smelled. Show the children how to wave their fingers over the top of the jar to send the scent to their noses. If you put your nose directly over something and inhale deeply, you may get too strong a smell at once.

Have each group experience with their own jar and then observe another group's jar.

INTELLECTUAL DEMANDS OF THE ACTIVITY

To do this activity the child is expected to observe that the smell of the liquid will come through the paper. The child is expected to realize that matter is ultimately made up of particles much too small to be directly observed.

ANALYSIS ACCORDING TO PIAGET'S STAGES

Three of the characteristics for Stage 1 of the Science 5/13 Program suggest that this activity is appropriate for children at the Grade Two level. These are:

1. enjoyment in using all the senses (Characteristic # 36, p. 40)
2. awareness that there are various ways of testing out ideas and making observations (Characteristic # 39, p. 40)

This activity can be categorized as suitable.

56. ACTIVITY (p. 122)

Have the children play with clay. They can shape the clay into a ball, a long string, a human or animal form, but it will still be clay. Ask: What caused the change in the clay? Ask the same question about each of the other pictures on pages 122 and 123: frying an egg, leaves coming on a tree, a boy riding a bike, the cutting of a lawn, a demolished car, a waterfall drying up, a tadpole developing into a frog.

INTELLECTUAL DEMANDS OF THE ACTIVITY

After the child works with the clay and then examines the different pictures, he is expected to be able to conclude that all changes are not the same. Some involve changes in temperature, some in shape, texture and composition. Some can change back and some cannot.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), a child at the concrete operations stage is becoming more aware of the relations that exist between separate events (Characteristic #94, p. 45). This would suggest that a child at this stage will be able to determine the cause of the changes that have occurred in the pictures. He should be able to see the relationship between the first pictures, in each case, and the end-products.

However, the Science 5/13 Program suggests that even at Stage 1 the child has an awareness of cause-effect relationships (Characteristic #67, p. 42).

Considering that the child in Grade Two is operating at Stage 1 of the Science 5/13 Program and could be in a transitional period between pre-operation and concrete operations, this activity can be deemed appropriate for a child at that grade level.

This activity can be categorized as suitable.

55. ACTIVITY (p. 120)

For this activity the children will need: crayons and drawing paper. Then have the children draw:

1. large building, the sun, etc.
2. big tree, big building, etc.
3. pencil dot, speck of pepper, etc.
4. tiny pebble, grain of salt, etc.
5. tall tree, tall building, TV tower, etc.
6. jet vapor trails, long street, etc.
7. large balloon full of helium, etc.

After all the children have finished their drawings, use them to illustrate the children's ideas about sizes. Their concepts about small, smallest, large, and largest should be broadened.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity the child is expected to draw pictures by following specific directions. His drawings will enhance his concepts of small, smallest, large, and largest.

ANALYSIS ACCORDING TO PIAGET'S STAGES

A child at Stage 1 of the Science 5/13 Program will have an awareness that the apparent size, shape and relationships of things depend on the position of the observer (Characteristic #69, p. 42). If a child is expected to have this awareness, then it should follow that he would also be aware that things that are seen as large or small are really large or small in a relative sense. This activity, then, is appropriate for a child at the pre-operational stage and hence Grade Two.

This activity can be categorized as suitable.

57. ACTIVITY (p. 125)

For this activity each small group of children will need: 1 crayon, 2 medium jars with lids, 5 5cm iron nails, 2 paper towels, 1 piece of sandpaper or steel wool, 1 roll of masking tape, and some water.

Have the children first scratch the nails with sandpaper or steel wool. This will enhance the results. Then ask them to place a few nails on a dry paper towel that is in jar "A". Have them place a few nails on a wet paper towel that is in jar "B". Close each jar. Ask the children to make a label for each jar by using crayon to print the letter "A" or "B" on tape. Ask them to make predictions about what will happen in each jar.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity, the child is expected to make predictions about the effect of water on iron.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Beard (1969), a child at the formal operations stage can make hypotheses and proceed to test them (Characteristic # 128, p. 47). In this activity a child hypothesizes about what will happen to the nail in both cases and then proceeds to test them by observing what happens over a period of time.

This suggests that this particular activity would be beyond the capabilities of the Grade Two child.

This activity can be categorized as unsuitable.

58. ACTIVITY (p. 126)

Have the children chew an unsalted soda cracker for as long as possible without swallowing it. How does the action of the teeth change the cracker? What kind of change is this? How does the taste of the cracker change after it is chewed for several minutes? Is this a physical or chemical change? Ask them whether a new material has been formed.

INTELLECTUAL DEMANDS OF THE ACTIVITY

Through chewing a cracker, the children are expected to answer questions about the changes that are taking place. They must have an understanding of the concepts of physical change and chemical change - which are very abstract concepts.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The concept of chemical change is a very abstract one and Copeland (1974) contends that children at the concrete operations stage are not ready for work at the abstract level (Characteristic # 95, p. 45). This would suggest that much of this activity would be more appropriate for a child at the formal operations stage, when as Copeland (1974) writes, "the child is at the abstract level" (Characteristic # 135, p. 48).

Questions such as:

1. How does the action of the teeth change the cracker?

and, 2. How does the taste of the cracker change after it is chewed for several minutes?

can be dealt with by children at the concrete operations and pre-operational stages because it involves using the senses to discover. Relating this change to chemical change, however, represents strong inference and according to one of the characteristics of Stage 3 in the Science 5/13 Program, a child at this stage will have the ability to use analogies to explain scientific ideas and theories (Characteristic # 156, p. 49). It can be assumed that the question involving type of change would be more appropriate for a child operating at Stage 3.

This activity can be categorized as unsuitable.

59. ACTIVITY (p. 126)

Have the children look for objects in the classroom or at home that have been nicked, dented, bent, broken, scratched or worn. What kind of changes are these? How might they have prevented or slowed these changes? Suggest they look for objects that have rusted, tarnished, or corroded. What kind of change do these represent? Invite the children to find out how people attempt to prevent or slow down these changes.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity with sufficient understanding, a child is expected to know the difference between physical and chemical changes. He must also become involved with investigation or research in order to find out how people attempt to prevent or slow down these changes.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The concept of chemical change is a very abstract one and Copeland (1974) contends that children at the concrete operations stage are not ready to work at the abstract level (Characteristic #95, p. 45). This would suggest that this part of the activity is more suitable for a child at the formal operations stage when as Copeland writes "the child can now reason or hypothesize with symbols or ideas rather than needing objects in the physical world as a basis for his thinking" (Characteristic #130, p. 47).

The concept of physical change can be handled by the average child at Stage 2 of the Science 5/13 Program when, as it is suggested, a child has an awareness of the changes in the physical environment brought about by man's activity (Characteristic #124, p. 47). However, consideration must be given to the fact that some physical changes might cause more problems than others due to the level of abstractness inherent in the change. The concept of condensation and evaporation is very abstract and would be better understood by children at the formal operations stage.

In conclusion, it can be assumed that this activity would not be a good match for a child at the Grade 2 level.

This activity can be categorized as unsuitable.

60. ACTIVITY (p. 127)

Have the children look at the picture and read the text at the top of page 127. Ask them to think about some changes that are caused by the weather. Then ask: (1) What do you think are some things that might have caused the soil to be worn away? (2) What might keep the soil in place? (3) Can you explain why the stone from the stream is smooth? (4) How might the sharp-edged stone be made smooth?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity the children must infer that weather conditions change things physically. Then they are expected to suggest some changes other than those that are caused by the weather.

ANALYSIS ACCORDING TO PIAGET'S STAGES

One of the characteristics of Stage 2 in the Science 5/13 Program which would seem to suggest that this activity is unsuitable for a child at the Grade Two level is:

1. Awareness of sequences of change in natural phenomena (Characteristic # 122, p. 46).

One of the characteristics of Stage 3 in the Science 5/13 Program suggests that inferences are better handled at that stage. It states that a child at this stage will have the ability to use analogies to explain scientific ideas (Characteristic # 156, p. 49).

This activity can be categorized as unsuitable.

61. ACTIVITY (p. 132)

Have the children identify, describe, and classify the 12 examples of changes illustrated in the picture pairs on pages 132 and 133 (uncooked and scrambled eggs, block of wood before and after whittling, tree with and without leaves, ice cube before and after melting, sandwich before and after it is eaten, wood planks before and after sawing, beach house before and after paint has weathered, car before and after washing, fabric before and after it is sewn, pile of leaves before and after burning, field before and after plowing). The children may work in groups and they can record their answers to the following questions about each change by placing letters in a chart like the one pictured on page 133.

1. Is the change chemical, physical, or both?
2. Is the change fast or slow?
3. Is the change natural or caused by people?
4. Can the things be changed back again?

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity, a child is expected to describe, identify and classify pictures of changes into categories.

The child will need to know how to classify with an understanding of certain concepts in order to handle the activity in a meaningful way.

ANALYSIS ACCORDING TO PIAGET'S STAGES

The part of this activity which is likely to cause most problems is the question, "Is the change chemical, physical, or both?"

The concepts of chemical change and sometimes physical change can be very abstract. Copeland (1974) contends that children at the concrete operations stage are not ready to work at the abstract level (Characteristic #95, p. 45). This would suggest that the first question might be more suitable for a child at the formal operations stage, when as Copeland (1974) writes, "the child can now reason or hypothesize with symbols or ideas..." (Characteristic #130, p. 47).

Classifying change as being fast or slow can be handled by children at the concrete operations stage, for according to Copeland (1974), at this stage children begin to use words that express mathematical relations between two objects (Characteristic # 93, p. 45).

Copeland (1974) also writes, "the child is becoming more aware of the relations that exist between separate events" (Characteristic # 94, p. 45) at the concrete operations stage. This suggests that a child at this stage may be able to see the relations that exist between what he sees in the pictures, and whether the cause is a natural one or one caused by people.

In conclusion, this activity is suitable for children at the late concrete operations or formal operations stages.

This activity can be categorized as unsuitable.

The analyses of the sample of activities for the unit on Matter indicated that of the 13 activities analyzed, 6 were found to be suitable and 7 unsuitable.

Table 5 shows these results.

TABLE 5

Summary of Findings for Unit on Matter

Unit: Matter		
Activity Number	Findings	
	Suitable	Unsuitable
49	X	
50		X
51	X	
52		X
53	X	
54	X	
55	X	
56	X	
57		X
58		X
59		X
60		X
61		X
Total	6	7

Analysis of Activities from Unit: PLANTS AND ANIMALS IN RELATIONSHIP WITH SPACE, TIME, ENERGY AND MATTER

62. ACTIVITY (p. 135)

Have the children look at the text and photos on pages 134 and 135. The photos show some events that herald the beginning of spring: (1) a rushing, muddy stream, (2) a red-winged blackbird, (3) some ants, (4) a spring flower, (5) a ground squirrel, (6) a frog, (7) a bee gathering pollen from a spring flower, (8) melting icicles.

Write the words "WINTER" and "SPRING" on the chalkboard. Then have the children think of as many differences as possible between winter and spring. Write their responses on the chalkboard under the appropriate heading.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity, a child is expected to investigate some of the signs of spring indicated by the pictures. Based on this experience and experiences they have had with seasons in their everyday life, children are expected to come up with as many differences as they can think of between spring and winter.

ANALYSIS ACCORDING TO PIAGET'S STAGES

Some of the characteristics of Stage 1 of the Science 5/13 Program indicate that this activity is suitable for this particular stage. These objectives are:

1. Awareness of changes which take place as time passes (Characteristic #42, p. 40).
2. Recognition of regularity in patterns (Characteristic # 44, p. 41).
3. Awareness of change in living things (Characteristic #46, p. 41).
4. Awareness of cause-effect relationships (Characteristic #67, p. 42).
5. Awareness of seasonal changes in living things (Characteristic #68, p. 42).

Since this activity involves finding concrete differences between winter and spring, it can be assumed that it is a good match for the child at the Grade Two level.

This activity can be categorized as suitable.

63. ACTIVITY (p. 139)

Have the children listen to some frogs and toads. Perhaps you are in a locality in which you can hear the call of frogs in the spring.

The best way to locate a pond for amphibians is to use your ears. Such a pond is one from which you can hear the loud, almost jingle-bell call of frogs called "spring peepers". Some other frog and toad spring calls are the almost dull twang (somewhat like a tuned-down banjo) of the green frog, and the long trilling call of the American toad.

INTELLECTUAL DEMANDS OF THE ACTIVITY

This activity requires that the child gain an increased awareness of spring by listening to animals in their environment, and keeping a concrete record.

ANALYSIS ACCORDING TO PIAGET'S STAGES

One of the characteristics of Stage 1 in the Science 5/13 Program indicates that children at this stage will enjoy using all the senses for exploring and discriminating (Characteristic # 36, p. 40). This suggests that children at the Grade Two level will be ready for an activity such as this which involves using the senses directly to observe frogs and toads.

This activity can be categorized as suitable.

64. ACTIVITY (p. 139)

Have the children listen to a woodpecker. Another spring sound that is often heard on spring mornings is that of a woodpecker. / If woodpeckers are found in your locality, you may wish to take your children outside to look for signs of woodpecker holes in trees.

INTELLECTUAL DEMANDS OF THE ACTIVITY

This activity requires that the child gain an increased awareness of spring by listening to and observing animals in their environment.

ANALYSIS ACCORDING TO PIAGET'S STAGES

One of the characteristics of Stage 1 in the Science 5/13 Program indicates that children at this stage will enjoy using all the senses for exploring and discriminating (Characteristic # 36, p. 40). This suggests that children at the Grade Two level (i.e., Stage 1) will be ready for this activity which involves using the senses to observe woodpeckers.

This activity can be categorized as suitable.

65. ACTIVITY (p. 145)

Ask the children to imagine that for some reason they had to spend the winter outdoors. What kind of protected place would they seek out or build for themsleves? Would it be like any of the hiding places shown on pages 140-143? Have the children draw pictures showing the features of the place they would find or build.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to draw a picture of a protected place they would want if they were to spend the winter outdoors, children will need to know the basic physical needs of human beings. Based on their knowledge, in this respect, children would then need to predict what their place would be like.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Copeland (1974), children at the concrete operations stages are becoming more aware of the relations that exist between separate events (Characteristic # 94, p. 45) and they are still very much a part of the physical world (Characteristic # 95, p. 45). This suggests that children at this stage will be able to see the relationship that exists between winter and what would be necessary in terms of shelter for that particular season. At first glance, then, it could be assumed that this activity would not be appropriate for children at the Grade 2 level.

However, this activity is concrete enough in terms of their everyday experiences to pose no problems for children operating at the pre-operational and early concrete operation stages.

This activity can be classified as suitable.

66. ACTIVITY

Divide the class into five groups, and give each group a soil sample. Have the children engage in a "How many different animals can you find?" game. Records could be kept on board charts or on group charts.

The soil samples should be placed on very large sheets of plain mural paper. The soil should be carefully teased apart with tweezers or toothpicks. Magnifying glasses will help children separate living objects from nonliving objects.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity, children must be able to identify very small animals and also be able to use a magnifying glass. This activity should develop an appreciation for how many different animals live in a small amount of soil.

ANALYSIS ACCORDING TO PIAGET'S STAGES

One of the characteristics of Stage 1 of the Science 5/13 Program indicates that identification of very small animals in a soil sample is an appropriate activity for this stage. It states that children at this level of development will have the ability to group things consistently according to chosen or given criteria (Characteristic # 45, p. 41). Furthermore, according to Copeland (1974), children at the early concrete operations stage are very much a part of the physical world and are not ready to work at the abstract level (Characteristic # 95, p. 45).

One can infer that because of the concrete nature of this activity, it is appropriate for a child at the Grade Two level.

This activity can be categorized as suitable.

67. ACTIVITY (p. 149)

Late in the spring, have the children set up a zoo of insects. By late spring many insects have emerged from hibernation, and they can be found all over the place. To do this activity one will need: some empty jars with lids that have holes punched in them. Have the children collect as many insects as they can, and try to group them by similar traits. For example, beetles have hard shell-like wing covers; most ants are wingless, etc. A nature guide to insects can be a great help in grouping these.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to do this activity a child must be able to classify and be able to use books to find pertinent information. He will also need to be able to observe and detect insects in their habitats.

ANALYSIS ACCORDING TO PIAGET'S STAGES

According to Beard (1969), a child at the concrete operations stage can classify in two or more ways simultaneously (Characteristic # 72, p. 42). This indicates that children would be able to do the classification of insects (which is involved in this activity) at the concrete operations stage.

One of the characteristics of Stage 2 in the Science 5/13 Program indicates that children at this stage will be able to select relevant information from books or other reference material (Characteristic #118, p. 46). It can be assumed, therefore, that children at the late concrete operations stage would be able to use a nature guide for information about insects which would enable them to be able to classify them.

However, children in Grade Two are generally operating at Stage 1, which indicates that this activity may cause problems for children at that grade level.

This activity can be categorized as unsuitable.

68. ACTIVITY (p. 155)

In emphasizing the importance of warmth and moisture for many plants to resume growth, the children can record the increasingly warmer temperatures of spring by observing the air temperature outside their classroom window over several weeks. It is necessary to have: a thermometer, chart paper, construction paper, scissors, paste, and a felt-tip pen. Be sure to have them take their readings at the same time each day. You might want to have a few children responsible for recording the temperature and an observation of plant changes each day. They could cut a strip of paper to a length which corresponds to the temperature for that day, and paste it on a bar graph. As the bars increase in length the children should gain a visual appreciation for the gradual rise in air temperature over several weeks.

INTELLECTUAL DEMANDS OF THE ACTIVITY

In order to carry out this activity a child must be able to read a thermometer and then record the temperatures on a bar graph. While checking the temperatures each day the children are also expected to be observing the changes in plantlife.

ANALYSIS ACCORDING TO PIAGET'S STAGES

At Stage 2 in the Science 5/13 Program one of the characteristics states that children will have the ability to use histograms and other simple graphical forms for communicating data (Characteristic # 120, p. 46). It can be assumed that this part of the activity which involves the bar graph would be beyond the capabilities of the average Grade Two child (who is operating at Stage 1).

Another characterisitc of Stage 2 suggests that this activity is more suitable for a child at this level. It states that a child at this level of development will have knowledge of ways to investigate and measure properties of non-living materials (Characteristic # 116, p. 46). This part of the activity, therefore, which involves reading the temperatures is not suitable for the average Grade Two child.

Finally, at Stage 2 one of the characteristics states that children will have an awareness of sequences of change in natural phenomena (Characteristic # 122, p. 46). This suggests that children at Stage 1 (or Grade Two) would have problems dealing with this part of the activity which involves changes in plantlife.

This activity can be categorized as unsuitable.

The analyses of the sample of activities for the unit on Plants and Animals in Relation to Space, Time, Energy and Matter indicated that of the 7 activities analyzed, 5 were found to be suitable and 2 unsuitable.

Table 6 shows these results.

TABLE 6

Summary of Findings for Unit on Plants and Animals in Relation to Space, Time, Energy and Matter

Unit: Plants and Animals in Relation to Space, Time, Energy and Matter		
Activity Number	Findings	
	Suitable	Unsuitable
62	X	
63	X	
64	X	
65	X	
66	X	
67		X
68		X
Total	5	2

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

The Grade Two Science Program in Newfoundland and Labrador is the STEM Science Program (STEM denotes the main topics of the program: Space, Time, Energy, Matter). While some schools may use certain other materials, STEM remains the program commonly used, as recommended by the Department of Education. This being the case, it was considered important that it be an exceptionally good program that meets the needs of the children for whom it is intended. It was deemed necessary to examine this program in light of some theory of child development, to determine to what degree there exists a match between the activities outlined in the Grade Two text, and the development and abilities of the Grade Two child. It was established that the majority of Grade Two children are seven years old.

For the purpose of this study, the literature was reviewed with special emphasis placed on:

(i) the developmental theory of Jean Piaget

(ii) the concept of matching, and

(iii) matching in science.

Piaget's developmental stages were used also as the basic guide to the mental capacities of the seven-year old. The selected activities in the Grade Two STEM Science Program were analyzed in light of these capacities.

In reviewing the literature on the developmental theory of Jean Piaget, it was discovered that the average Grade Two child (who is essentially seven years of age) is operating in the pre-operational stage of development, or is in a transitional period between the pre-operational and early concrete operational stages, or at best, is in the early concrete operational stage.

Research studies on the concept of matching indicate that appropriate learning experiences should be provided for children, regardless of their grade level. In order to ensure a match, one must first ascertain, insofar as possible, the level of reasoning of the child and on this basis, select activities which are within the intellectual capabilities of the child.

An examination of the literature related to matching in science revealed that Piaget's theory is particularly relevant to science teaching, because it deals with the capabilities of children at different levels to perform certain logical operations, which are directly related to some of the processes of science. Piaget described the development of science concepts through his four developmental stages: the sensori-motor stage, the pre-operational stage, the concrete operations stage and the formal operations stage.

The literature revealed also that Piaget's developmental stages were used as the basis for the development of activities included in a well-known science program for children: British Schools Council Science 5/13 Program (Ennever et al., 1972). For the purpose of that particular program three developmental stages were used: Stage one representing the transition from intuition to concrete operations and the early stage of concrete operations; stage two representing the later stage of concrete operations, and stage three representing the transition from concrete operations to the stage of abstract thinking (i.e. formal operational thought).

On examination of the Grade Two STEM Science Program (Teachers' Edition), it was discovered that there were a total of 270 activities. An analysis of all of these was seen as impractical and difficult to manage. Instead it was felt that a sample of approximately 25 percent of the total activities chosen randomly and representing the various units of the text would constitute a valid sample of the total activities.

A table of random numbers (Glass and Stanley, 1970) was used for the selection process. The sample included 68 activities, which represented the various units of the text as follows: Living Things - 18 from a total of 74; Space - 8 from a total of 29; Time - 10 from a total of 41; Energy - 12 from a total of 39; Matter - 13 from a total of 49; and Plants and Animals in Relation to Space, Time, Energy and Matter - 7 from a total of 38.

Each of the selected activities was analyzed in the following manner:

(i) a description of the activity was given

(ii) a description of the intellectual demands of the activity was given

(iii) the analysis of the activity, according to Piaget's stages, was carried out.

The results of the analyses of the activities were recorded by categorizing them as being suitable for a child at the following developmental stages (Stage 1, Stage 2 and Stage 3 refer to those of Ennever et. al., 1972):

(i) the pre-operational, early concrete/Stage 1

(ii) the concrete operations stage/Stage 2

(iii) the formal operations stage/Stage 3.

It was earlier established that, according to the criteria used for the purpose of this study, in order to be appropriate for Grade Two children (most of whom are 7 years of age), an activity must fall into the first category (i.e. the pre-operational, early concrete/Stage 1).

The limitations inherent in the study were:

(i) Activities from the printed page were examined in terms of suitability, as opposed to observing children carrying out these activities. The latter was not feasible. For children of the age level in question, active involvement in concrete situations is a major factor in learning. This factor, combined with the differences in ability and experiences which are bound to be a feature of a sample population of children, might well have changed the outcomes of the study.

(ii) A random sample of activities from the Grade Two STEM Science Program was examined, which, despite appropriate sampling procedures, may or may not be representative of the total program.

Each activity in the sample was analyzed and categorized as suitable, or unsuitable for Grade Two children. A summary of the findings for each unit is given in Tables 1-6. Of the 68 activities examined, 38 were found to be a good match for the pre-operational, early concrete/ Stage 1 (and, therefore, for Grade Two children); 30 were deemed more suitable for children at the late concrete operations and formal operations stages (or Stage 2 and Stage 3 of the Science 5/13 Program). A further analysis of suitability of activity by unit revealed that the activities in the unit on "Living Things" were appropriate, 14 of the 18 activities examined being suitable for children in Grade Two. In the unit on "Space", 5 of the 8 activities examined were found to be suitable for children in Grade Two. In the unit on "Time", 3 of the 10 activities examined were found to be suitable for children in Grade Two. In the unit on "Energy", 5 of the 12 activities examined were found to be suitable for children in Grade Two. In the unit on "Matter", 6 of the 13 activities examined were found to be suitable for children in Grade Two. In the unit on "Plants and Animals in Relation to Space, Time, Energy and Matter", 5 of the 7 activities examined were found to be suitable for children at the Grade Two Level. These findings are presented in Table 7 on page 139.

Recommendations

The overall results of the examination of the Grade Two STEM Science Program indicate that 44.1 percent of the sample of activities examined appear to be unsuitable for Grade Two children. These activities provide a better match for children operating at the late concrete operations/Stage 2 and the formal operations/Stage 3 levels of development, than for the children at whom they are currently directed. On the basis of these findings certain recommendations can be made.

1. Provided the STEM Science Program is retained as the basic Science text for Grade Two children, the following revisions should be considered:

   (i) The unit on "Living Things" can be deemed appropriate for the children at the Grade Two ~~level~~. Fourteen of the eighteen activities examined in that unit were analyzed as being suitable for the Grade Two children.

(ii) The unit on "Space" can be deemed appropriate for children at the Grade Two level. Five of the eight activities examined in that unit were analyzed as being suitable for Grade Two children.

(iii) The unit on "Time" should be examined more closely and consideration given to providing a supplementary set of activities. Only three of the ten activities analyzed in that unit were deemed suitable for Grade Two children.

(iv) The unit on "Energy" should be examined more closely and serious consideration given to providing a supplementary set of activities. Five of the twelve activities analyzed from that unit were deemed suitable for Grade Two children.

(v) The unit on "Matter" should be examined more closely and serious consideration given to providing a supplementary set of activities. Only six of the thirteen activities analyzed from that unit were deemed suitable for Grade Two children.

(vi) The unit on "Plants and Animals in Relation to Space, Time, Energy, and Matter" can be deemed appropriate for children at the Grade Two level. Five of the seven activities examined in that unit were analyzed as being suitable for Grade Two children.

2. The Department of Education might consider a revision of the Grade Two STEM Science Program.

3. In light of the findings of this study, it is recommended that further research be undertaken with respect to the STEM Science Program in the Primary school. It would be profitable to examine the Kindergarten, Grade One and Grade Three Programs in a manner similar to that used in this study and where feasible, to actually observe children attempting to perform the selected activities in a classroom situation.

TABLE 7

Summary of Findings for the Total Sample of Activities

Unit	Total Activities Examined in the Unit	Suitable Activities	Unsuitable Activities
Living Things	18	14	4
Space	8	5	3
Time	10	3	7
Energy	12	5	7
Matter	13	6	6
Plants and Animals in Relation to Space, Time, Energy and Matter	7	5	2
Total	68	38	30

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