A CASE STUDY OF THE DEVELOPMENTAL DIFFERENCES IN PATTERN PROCESSING ABILITIES IN YOUNG CHILDREN

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by

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ABSTRACT

This study was undertaken because of the perceived need for information regarding how young children process patterns. The purpose of the study was to look into the pattern recognition abilities of young children. Specifically, the abilities of children at different levels of development, within a Piagetian framework, were examined. A review of the literature revealed the variables which had been shown to be relevent to pattern recognition as well as the various explanations for how patterns are processed.

A case study research design was decided upon and a purposive sample was chosen of 97 children from grades one and two in a rural school in Newfoundland. The group's mean age was 90.64 months.

The sample was first administered several standard Piagetian-type tasks which differentiated conservers from non-conservers. Several observations were made regarding the role played by age as a variable in level of development, and the role played by school experience as a variable in level of development. Specific sub-groups of the original sample were defined as Pre-Operational and Concrete Operational based on the findings from the Piagetian instrument.

Finally, these two sub-groups were given several patterning tasks in which they were required to extend a

given pattern. The results from this instrument were examined to compare the two groups on rate of success, the tendency to impose a pattern in an erroneous response and the type of errors committed.

The data was analyzed using non-parametric statistics, and results were not generalized beyond this sample.

The findings seemed to show that while age did not seem important as a variable in determining Piagetian level, grade level did seem to show importance as a variable. Also, developmental level did seem to differentiate the more successful pattern solvers from the less successful. Error types seemed to vary for the two levels, however both groups seemed predisposed to imposing a pattern, even in an erroneous response.

The thesis concluded with a set of recommendations for researchers and educators.

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CHAPTER I

THE PROBLEM

Introduction

> Patterns are everywhere.
>
> Our lives are surrounded and often governed by patterns. Daily outlines lead us to anticipate about when the morning paper will arrive, when the bus will be at the corner, or when lunch will be served. In nature, flowers and leaves form symmetrical patterns; the sun, earth and moon rotate in patterns; and the seasons follow patterns (Barnett, 1982, p. 9).

Our ability to function in the environment is largely due to the fact that there are so many naturally occurring patterns. These give one a sense of constancy; they provide a basis for predicting future events and thereby allow us the structuring of lives into routines. Klahr and Wallace (1970) state that:

> the ability to detect environmental regularities is a cognitive skill essential for survival. Man has a propensity to seek and a capacity to find serial patterns in such diverse areas as music, economics and the weather (p. 243).

Our desire for regularity and pattern are so intense that we often cannot deal with events which are chaotic. It seems to be an innate inclination to attempt to organize even the most haphazard of events. "Even when no true pattern exists, humans attempt to construct one that will enable them to predict the sequence of future events" (Klahr & Wallace, 1970, p. 243). "There is no doubt that we feel some deep need for order and pattern" (Marjoram, 1974, p. 16).

Nowhere is pattern more evident than in mathematics. The structure of mathematics is based upon the regularities and intricate patterns of relationships between the various elements. Several authors have taken the liberty to define mathematics in terms of patterns. "Mathematics is the classification and study of all possible patterns," according to Sawyer (1955, p. 12). Marjoram (1974) sees mathematics as "an activity concerned primarily with argument, with spotting patterns and posing premises" (p. 3). One of the best definitions of mathematics, for Dawes (1977) "is that it is the recognition and the study of patterns. These patterns refer to any regularity that our minds can recognize" (p. 1). Similarly, Sueltz (1976) defines mathematics as "the study of structure and relationships and the discovery of principles and patterns" (p. 3). There seems to be agreement in the literature on the fact that mathematics is a discipline governed by patterns. Indeed, to have a grasp of the structure of mathematics is to see the patterns which are crystalized within.

In the field of mathematics education, it is the job of teachers to provide their students with experiences which will lead them in development toward an understanding of the subject area. It is not enough to provide disjoint experiences that aim for shallow learning. Rather the long term aim should be to guide children to a vision of the structure of mathematics. "Researchers and curriculum developers oriented toward conceptual approaches seem to agree on the importance of fostering in children a strong intuitive understanding of the underlying structures of mathematics." (Resnick and Ford, 1981, p. 101). At the famous Woods Hole conference in 1959, which brought together prominent mathematicians and educators, it was a major agreement that the teaching of mathematics must be influenced by this goal.

> The curriculum of a subject should be determined by the most fundamental understanding that can be achieved of the underlying principles that give structure to that subject. Teaching specific topics or skills without making clear their context in the broader fundamental structure of a field of knowledge is uneconomical in several senses. In the first place, such teaching makes it exceedingly difficult for the student to generalize from what he has learned to what he will encounter later. In the second place, learning that has fallen short of a grasp of general principles has little reward in terms of intellectual excitement ...Third, knowledge one has acquired without sufficient structure to tie it together is knowledge that is likely to be forgotten (Bruner, 1960, p. 31).

If then the goal is to teach mathematics for structure we cannot be justified if we do not help our children to see the patterns which, by definition are the basis of the mathematics. Thus, in this global sense, there is a sound rationale for experiences in pattern to be part of the mathematical curriculum in our schools. At a more immediate level, the inclusion of pattern experiences in the curriculum can be rationalized in terms of their basis in problem solving.

Problem solving has been seen as the underlying goal of all education. Heathers in Mendoza (1977) suggests that "problem solving thinking or inquiry is generally considered to be the core of the educational process and the chief mark of the educated person" (p. 135).

Problem solving is one the most basic aspects of any mathematics program. The Priorities in School Mathematics (P.R.I.S.M.) report of 1981, cited as one of its recommendations that problem solving be a major organizing element in the mathematics curriculum (Worth, Cathart, Kieren, Worth and Forth, 1981). An Agenda for Action (The National Council of Teachers of Mathematics, 1980) also suggested that problem solving be the focus of school mathematics in the 1980's.

When solving problems, often clues to the solution are present in the form of patterns in the data or information. Seeking out these patterns enables one to organize the given information into a more understandable, useable picture (Whimbey and Lochhead, 1981). Among the skills which were deemed crucial to problem solving by elementary and secondary teachers surveyed for the P.R.I.S.M. report, the ability to seek out patterns in data ranked highly (Worth et al., 1981). The literature seems to concur that pattern detection is one of the more fundamental problem solving skills.

> Discovering patterns is a very important strategy in problem solving. In mathematics, we refer to examining a variety of cases, discovering patterns, and forming conclusions based on these patterns as inductive reasoning (Billstein, Libeskind and Lott, 1981, p.2).

It is unfortunately quite common in mathematics in schools that problem solving activity is not emphasized in primary and elementary grades. And equally unfortunate is the belief that many high school students do not solve problems very well. Especially difficult are novel problems which stray from the well-worn path of simple computation. Such problems as detecting patterns inherent in a series of numbers for example 1, 3, 6, 10..., or detecting patterns in geometric designs, for example the number of squares on a checkerboard pose roadblocks to many high school students. The heroic efforts put forth by high school mathematics teachers to teach strategies for solving problems do not seem to be enough. Perhaps this is far too late to begin preparing students to solve problems.

Jerome Bruner once said that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (Bruner, 1960, p. 31). As controversial as this statement has been, it can be applied quite readily to the area of problem solving. Problem solving has been defined as seeking "to answer a question for which that individual has no readily available strategy for determining the answer" (DeVault, 1981, p. 40). There are many such questions which can be posed at an early childhood level. The National Council of Teachers of Mathematics saw fit to dedicate an entire chapter of their 1975 yearbook, Mathematics Learning in Early Childhood to the subject of problem solving in early childhood. It is not difficult to find evidence of agreement that "mathematics programs of the 1980's should involve students in problem solving by presenting applications at all grade levels" (Payne, 1975, p. 4). Bruner's idea of the spiral curriculum (1960) is additional evidence that problem solving, like other skills and concepts, should begin at a basic level in early childhood, and should develop and expand through the child's schooling. If, as it was stated earlier, pattern recognition is thought to be a major problem solving skill, then it seems apparent that it should be included as part of the primary school mathematics.

The Need

In the province of Newfoundland at the time of writing, the mathematics textbook series used in primary and elementary schools is Investigating School Mathematics (Eicholz, O'Daffer and Fleenor, 1973). Because the I.S.M. series is supposedly modelled on Bruner's spiral curriculum, one would assume that pattern recognition skills are a part of the primary textbooks. In fact, this series was examined by the writer to see what, if any exposure to patterns the children would have obtained, from kindergarten to the end of grade three. If the teachers did not use resources outside of the textbooks, the children would have completed one page of completion of patterns in kindergarten (Eicholz et al., 1973, p. 16) and one page of coloring of patterns in grade two (Eicholz et al., 1973, p. 10 f yellow).

Even primary teachers in eastern Newfoundland who recognize a need for more work on patterns will face difficulty in finding appropriate supplementary material. At the time of writing, the Curriculum Materials Centre of the Faculty of Education (Memorial University of Newfoundland) had no material suitable for the teaching of patterns in primary grades. Likewise, the Resources Clearninghouse (Memorial University of Newfoundland) and the Instructional Materials Division of the Department of Education (Government of Newfoundland and Labrador) were found to be void of any such material. Typical primary schools, especially kindergarten classrooms, in Newfoundland are usually equipped with at least one set of colored beads for stringing, however any suggestions for games or activities to use this material to teach patterns is virtually non-existant. In summary, teachers are largely left to their own ingenuity when attempting to teach patterns in the primary grades. Sternberg (1975) has noted the generality of this deficit.

Not only is there a notable absence of instructional material available for the teaching of patterns, but there is a real lack of knowledge about children's ability to process patterns. The literature has little to offer in explanation of what kinds of patterns children can process, how they develop the ability to process patterns and what the prerequisite behaviours for this ability are. The problem lies in the fact that activities suitable to help children develop these patterning abilities cannot be designed unless more knowledge is gleaned regarding the above questions. This type of need is a basic purpose for much educational research.

> The basic problem is to provide instruction that is appropriate for individual students' level of cognitive development ...The problem for research is to identify the specific limits for each stage of development and to describe how instruction that is consistent with these limits can be designed (Carpenter, 1980, p. 187).

The Purpose

It was the purpose of this study to look into the pattern recognition abilities of young children. Specifically, the abilities of children at different levels of development were to be looked at. To accomplish this, children were examined on a variety of conservation-type tasks to determine their Piagetian stage of development. Within this framework, the variables of age and grade level were examined to determine whether or not they played an important factor in distinguishing between the developmental levels.

The rates of success on several pattern items of two developmentally different groups were examined in an effort to decide whether or not development was a key factor in pattern processing. To gleen further insight into how the young mind processes a pattern, the errors in the pattern tasks of children at the two distinct levels of development were examined. This examination of errors was performed in an attempt to see how the child processed the stimulus information even when he or she could not comprehend the given pattern. The childrens' errors were coded on the existence of some structure or repetitive pattern, albeit not the stimulus pattern, as well as on the exhibition of certain tendencies with respect to identifiable error types.

The information sought was later formalized into a set of specific questions.

Definition of Terms

Pattern - any linear sequence of objects in which repetition of a defined period is visually obvious.

Period - any linear sequence of objects in defined order which is capable of being repeated.

Perseveration* - the tendency to continue a string of one color. For example, in the pattern BLUE YELLOW YELLOW BLUE YELLOW YELLOW, a subject would show perseveration if he or she continued the pattern with YELLOW YELLOW YELLOW ..., while ignoring the BLUE.

Alternation* - the tendency to continue a string of alternation of two colors. For example, in the pattern BLUE YELLOW YELLOW BLUE YELLOW YELLOW, a subject would show alternation if he or she continued the pattern with BLUE YELLOW BLUE YELLOW ... .

Pre-Operational - for the purpose of this study, children will be classified as Pre-Operational if they give seven or more "incorrect" responses on the Piagetian instrument.

Transitional - for the purpose of this study, children will be classified as Transitional if they give four, five or six "incorrect" responses on the Piagetian instrument.

Concrete Operational - for the purpose of this study, children will be classified as Concrete Operational if they give seven or more "correct unassisted" responses on the Piagetian instrument.

* It is noted that these terms have a broader definition in psychology, however, for the purposes of this study, they will be limited to their application to the situation of patterns.

Questions

#1. Is there any difference between the distribution of children at the Pre-Operational, the Transitional and the Concrete Operational stages at the grade one level and this distribution at the grade two level?

#2. Is there any difference between the mean ages of the Pre-Operational, the Transitional and the Concrete Operational groups?

#3. Is there any difference in the rate of success on the patterns tasks between the Pre-Operational group and the Concrete Operational group?

#4. Does the Pre-Operational group differ from the Concrete Operational group in the proportion of subjects who, in an erroneous response, imposed a pattern?

#5. Is there any difference between the Pre-Operational group and the Concrete Operational group in the proportion of perseveration-type errors that they make?

#6. Is there any difference between the Pre-Operational group and the Concrete Operational group in the proportion of alternation - type errors that they make?

#7. Does the Pre-Operational group differ from the Concrete Operational group in the item on the patterns instrument on which the largest number of errors were made?

Scope and Limitations

This study will be conducted as a case study of a small group of children in a rural Newfoundland community. Case studies have recently come into focus as a credible form of educational research methodology especially in light of the fact that it is a frequently used format in the noted Soviet Studies in the Psychology of Learning and Teaching Mathematics (Kilpatrick and Wirzup, 1970).

Nevertheless, there are admittedly some serious limitations in this type of study. The greatest limitation of any case study is its generalizability. When no population has been identified and the sample is not random, one cannot state with certainty that what holds true for the subjects under consideration in a particular study is true for any larger group. However, it is fair to say that while children who have had specific kinds of background experience will be unique in some aspects, the basic developmental process according to Piaget has been proven to be generally consistent in sequence and in it's characteristics in children throughout the world. Therefore any trend found prevelent in this group of children might lead to speculation that this or similar trends exist in general.

In this study, two groups of children which will be identified as Pre-Operational and Concrete Operational by the specified criteria, will be compared on patterning tasks. To ensure that reasonable size groups were found it was decided to test all of the grade one and grade two children. Grade two children will have had more experiences with mathematics which may or may not influence rate of success on the pattern tasks. As stated in "The Problem", the current mathematics program for Newfoundland contains very minimal work on patterns. Thus the expected influences of instruction on patterns is very slight, if at all. However, other experiences in mathematics may be influential and it is acknowledged that this too will affect any generalizability of this study.

Having defined the problem to be resolved, a review of the relevent literature in the area of mathematics education, and more specifically pattern processing was undertaken. The information gathered was organized into four sections and is contained in the following chapter.

CHAPTER II

REVIEW OF RELATED LITERATURE

The review of the literature on the pattern abilities of young children which follows will be divided into four sections. The first section will include the literature concerning the kinds of patterning behaviours found in young children. The second section looks at what research offers by way of explanation of how children process patterns. A third section will involve what are seen as the prerequisite behaviours for successful pattern processing. Finally, a discussion of the major variables which have been identified as relevent to pattern processing research, will comprise the fourth section.

Abilities Related to Pattern Processing

Young children show evidence of a great many mathematical behaviours. This is evident from studies which have been done on children from infancy to adolescence. Indeed, in terms of pattern related abilities, this assertion seems hard to dispute.

At a very basic level of patterning skill, several studies have tested young children's ability to match a given sequence by direct copying of it. One such study, conducted by Pufall and Furth (1966), tested subjects of ages four, five and six on various copying tasks. The subjects involved in this study, at all three age levels, could copy the particular linear sequence given with a high degree of success. This result was substantiated by Brown and Murphy (1975) in a replication of Piaget's clothesline task. Subjects were presented with a minature clothesline from which hung a particular arrangement of paper cut-out clothing. The subjects were then given an empty clothesline of their own, with a pile of the cut-out clothes and were instructed to produce an identical arrangement. The subjects, ranging in age from three years, one month to five years, nine months (mean age four years, eight months) exhibited a high degree of success, contrary to Piaget's own findings that subjects younger than five years of age were quite unsuccessful (Brown and Murphy, 1975, p. 311). However, when dealing with non-linear or matrix stimuli, Chap and Ross (1979) found that their five and six-year old subjects made a "substantial number of perceptual copying errors" (p. 203).

Research by Frith (1970) concentrated on errors made in pattern completion tasks by normal children of ages ranging from five years, two months to six years, three months and autistic children in the chronological age range of seven years, three months to fifteen years, one month, but with a mean mental age of three years, two months. One very prominent discovery made was that even when the normal children did not complete the given pattern correctly, most of the time some pattern was imposed.

Furthermore even the autistic children seemed to have a real propensity to impose a pattern, even when it was not the stimulus pattern. In a second study, Frith's subjects were required to predict the next color in a two color arrangement when the only clues given were acknowledgement of the correctness of their guesses. Even though the stimulus arrangement was random, the children's guesses showed "highly predictable pattern" (p. 131). A third experiment in this study by Frith concerned a group of normal, sub-normal and autistic subjects in a situation where they were encouraged to make their own patterns. The success rate for imposing patterns was high in general, but perhaps a very surprising finding was that while 85% of the normal children produced irregular patterns, 75% of the sub-normal and autistic children produced strictly regular patterns. These normal children were of chronological ages three years and five years as compared with the sub-normal and autistic children whose mental ages were three to four years.

In a pattern recognition test conducted on pre-kindergarten, kindergarten and grade one children of low socio-economic status, Sternberg and Larson (1976) found that the success rate of the young children (pre-kindergarten) was close to chance. This result was substantiated by Scandura and McGee (1972) who set out to determine the processing skills of five year old subjects, and to discover the effects of selected learning experiences on these abilities. With an original success rate of slightly less than 50%, the treatment caused a positive change in success. At a more advanced level, Blackall (1975) studied the success of grade three children to solve an extensive array of patterns both linear and matrix, involving geometric shape and number. She found that in general, grade three children can solve a wide variety of patterns. Cromie (1971) also tested pattern processing abilities in pre-kindergarten, kindergarten and grade one children and found that they were on the whole successful, with mean grade level scores ranging from 59% to 92%.

The Processing of Patterns

The literature on pattern processing abilities in children in general is meagre, however it is particularly so in the area of analysis of how children process patterns. Scandura (1971) identified "the ability to detect mathematical regularities" (p. 6) as one of six basic intellectual processing skills. However, he noted the near absence of research regarding the techniques for detecting patterns:

> Although such techniques are notoriously hard to pindown in detail, they are clearly important to learn and use. They have been shown to be helpful in a wide variety of situations, and more attention should be given to them in mathematics education (p. 16).

Bartlett (1958) agrees that "on one has adequately explained how humans extract rules" (p. 43).

The processes involved in patterning have been explained via an information processing model by Simon and Kotovsky (1963) who attempted to simulate human patterning processes with a computer program. They discovered that to recognize a pattern, the computer had to translate the pattern sequence into a general rule or pattern description. To do this the computer first had to discover the periodicity in the sequence, or the length of the original set to be repeated. It accomplished this by "looking for a relation that repeats at regular intervals...Once the basic periodicity has been discovered, the details of the pattern are supplied in almost the same way - by detecting and recording the relations - of equal and next - that hold between successive symbols within a period or between symbols in corresponding positions of successive periods" (p. 540). These processes, then, are assumed to generalize to human subjects (p. 541).

Another pair of researchers who have attempted to explain pattern processing via information processing are Klahr and Wallace (1970). Like their predecessors, Klahr and Wallace also want to generalize human processes in patterning from the processes used by a computer. From their research, they have attempted to explain strategies which are likely used by humans.

The first of these is template construction. "The evidence suggests that some subjects solve these problems by constructing templates of increasing size until they find a recurring pattern" (Klahr and Wallace, 1970, p. 245). This procedure involves the subject trying each segment as the period beginning with the single first item, then moving to the first plus second items, on to the first plus second plus third items, etc., until the recurrancy is found. Each trial period is tested along the series, and when a mismatch is discovered, this period is abandoned and the next one tried.

Another strategy which may explain the patterning process is "backward scanning in which a template of the last few objects in the series is matched against the problem" (Klahr and Wallace, 1970, p. 247). This differs from template construction in that it works from the right side of the sequence backwards as opposed to working from left to right.

The information processing models described above may be thought of as presenting a behaviorist oriented model for pattern solving. While they may offer some plausible explanations of how children process patterns, Restle (1970) contends that "none of the five conventional stimulus-response theories of serial learning can handle even the simple data of serial pattern learning...such theories take no proper account of the intrinsic organizing possibilities in the sequence" (p. 482). A cognitive model of processing ability would likely assert that children have some innate predisposition; that they bring some natural mathematical or logical reasoning skills to the pattern task. Such abilities are difficult to study, however researchers have found that much insight can be obtained from an analysis of the errors committed by children in a pattern task.

Bartlett (1958) studied the pattern task of extrapolation and found that the most common mistakes involve "discovering some single rule and then neglecting others for which there is evidence" and "missing out steps of application" (p. 47).

Frith (1970) analyzed the errors made by his normal and autistic subjects in terms of their relationship with the pattern given. He identified two types of dominant features in his patterns. One of these he called perseveration. These are the type which seem to encourage repetition of one particular part of the period while not the period as a whole. For example, in a color pattern in which the period is BLUE YELLOW YELLOW, the tendency might be to continue with all YELLOW. The other dominant feature identified by Frith was alternation. Alternation patterns are those which seem to encourage continuation in the form of alternation of the elements. For example in a color pattern in which the period is BLUE YELLOW BLUE, the tendency might be to continue with a string of YELLOW BLUE YELLOW BLUE...instead of BLUE YELLOW BLUE BLUE YELLOW BLUE.

Findings in Frith's research can be summarized as follows:

> Most errors made by normal children were in accordance with the dominant feature of the patterns. Most errors made by autistic children were due to the imposition of simple perseveration or alternation strings independent of the given pattern...It is concluded that autistic children are insensitive to differences in the structures present and tend to impose their own simple stereotyped patterns, while normal children impose such patterns in absence of structured input only (p. 120).

Whether or not the responses of the autistic children, whose mean mental age was three years, two months, can be compared in any way to normal children of the same mental age is unclear, so generalizations regarding developmental differences in terms of processing tendencies cannot be made here. However, Gerjuoy and Winters (1968) have given credit to the notion that young children, generally under five years of age show perseveration tendencies which differ from children of older than five years who seem to show alternation tendencies. They claim that simple response preferences in young children take into account only one previous stimulus, which may shed some light on the errors made by normal children in Frith's study.

Variables Associated with Pattern Processing

Studies on pattern recognition which were reviewed seem to point to the fact that there exist several major variables which seem to have some impact on children's success on pattern recognition tasks. The first of these variables is age. In a study which tested subjects' ability to match ordered sequences, Bass (1975) found that age was an important factor. The subjects' age range was approximately five years to approximately eight years, and Bass found that older children were more successful than younger ones. In a mathematical unit on patterning, McKillip (1970) found that for copying patterns, success varied according to age. Sternberg (1973) concurred "that there is an improvement with age in the ability to recognize specific pattern sequences" (p. 67). Blackall's study (1975) of a variety of patterning tasks was confined to children at the third grade level. Within this limited age range, age was found not to be a factor in patterning success. For Bragman and Hardy's deaf subjects, "the age of the subjects affected only the performance on the same pattern recognition but not on the total pattern on reverse pattern" (1979, p. 180).

The variable of developmental stage in Piagetian terms, which might be linked to age, has also been identified in the study of Blackall (1975). She tested her grade three subjects on Piagetian type tasks for conservation of number, conservation of area and classification. The Pearson Product-Moment Correlation Coefficient for area conservation and patterning success was judged significant for most of the pattern tasks, but not significant for a geometric linear completion task. Conservation of number was not significant when correlated with success on any of the pattern tasks. Blackall suggested that this result might imply that conservation was a prerequisite for all of the pattern tasks (p. 241). A significantly positive correlation was found between one of the classification tasks and success on one of the pattern tasks.

Previous experience has been measured by school background in terms of grade levels. Sternberg and Larson (1976) found that variability in pattern recognition correlated significantly with grade level and ability in combination. McKillip (1970) also noted that success varied according to age and previous experience. To support this, Cromie (1971) found that grade one subjects were more successful on pattern tasks than were kindergarteners, who were in turn more successful than pre-kindergarteners. Sternberg (1973) found that both of his pre-kindergarten groups scored low on pattern processing tasks as compared with kindergarteners and first graders. Considering that the ability levels of the pre-kindergarteners seemed not to show any significant difference in score, Sternberg hypothesized that "this may indicate that youngsters at this grade level cannot handle pattern tasks of this nature without instruction" (1973, p. 66).

Another interesting variable which has been studied is mathematical achievement. Blackall (1975) found that all correlations between mathematical achievement and each task on her pattern test were significant. She noted in particular that on the task called geometric: linear: continue the correlation was stronger with problem solving achievement than with achievement on mathematical concepts. Sternberg (1973) also found that achievement as a variable did show significant differences between groups on various pattern tasks. Bragman and Hardy (1982) found that there was no significant relationship between arithmetic achievement and identical pattern recognition in subjects of mean age six years, eleven months, but that there was a significant relationship between arithmetic achievement and reverse pattern recognition.

Related to mathematical achievement is intelligence and/or mathematical ability which have also been studied by Blackall (1975) and Sternberg and Larson (1976). Blackall studied intelligence and decided that, in general, intelligence correlated highly with success on each of her pattern tasks. She also noted that success on the geometric: linear: continue task showed a stronger positive correlation with verbal intelligence than with non-verbal intelligence. Sternberg and Larson found that pattern recognition ability only correlated strongly with ability level in combination with grade level.

Variables related to the actual pattern given have been examined. Pufall and Furth (1966) found that concrete sequences seemed easier for their four to six year old subjects than did pictoral sequences. This substantiates Piaget's and Bruner's claim for the necessity of concrete experiences at this level (Copeland, 1974; Bruner, 1960). This contrasts Cromie's (1971) findings that his subjects performed better on iconic (pictoral) tasks than enactive (concrete) ones.

Blackall (1975) created a hierarchy of pattern tasks which involved a combination of extending the length of the period, varying the amount of information given and varying the number of attributes to be considered. Several of these aspects varied simultaneously, and it is therefore difficult to make any assumptions about which aspect in particular made the difference in difficulty.

Frith (1970) maintained that patterns whose dominant feature is perseveration were less difficult for normal children than patterns whose dominant feature is alternation. Within the perseveration dominant patterns, those with the repeated element at the right end of the period, for example, GREEN YELLOW YELLOW YELLOW were found to be more difficult than those with the repeated element at the left, for example, GREEN GREEN GREEN YELLOW. Within alternation dominant patterns, those with the alternating elements, as opposed to any repeating elements, at the right end of the period, for example, GREEN GREEN YELLOW GREEN were more difficult than those with the alternating elements at the left, for example, GREEN YELLOW GREEN GREEN. Cromie (1971) also found that an alternation type of pattern (ABAABA) was most difficult for the grade one subjects but surprisingly enough was least difficult for the kindergarteners.

Simon and Kotovsky's information processing model (1963) was used to make inferences about pattern difficulty and it was decided that the factors which helped rate patterns as more or less difficult were the length of the pattern description or rule, and the number of positions — the pattern filled in immediate memory. It was found that "the program was incapable of organizing the parts of the pattern into an overall structure when two immediate memory positions were involved" (p. 544). Again Cromie supports this claim in that his youngest subjects found most difficult those patterns with four elements as opposed to two or three (1971).

Several different tasks have been used to test patterning ability and these tasks have, in themselves been found to be a variable in determining success. Brown and Murphy (1975) studied young children in a copying task and they found that there was a difference in children's ability to copy a linear model which was directly opposite, or parallel to their own as opposed to the model being displaced or off to one side, the latter being more difficult. This distinction has also been found by Copeland (1974). Blackall (1975) identified several tasks which related to patterning and ranked these as follows. The task of interpolation, which involved the subject filling in missing elements of a given pattern of colored shapes, was found to be relatively easy. More difficult than interpolate was the task of continue, which involved the subject viewing a given segment of a pattern and then placing the appropriate colored shapes so as to extend the pattern according to the given rule. Even more difficult than continue was the task of reverse, where the subject was shown a segment of a pattern and told to give a segment which reversed the pattern. Bragman and Hardy (1972) too, noted that reverse pattern recognition was more difficult for their subjects of mean age six years and eleven months, than identical pattern recognition. Cromie (1971) concluded that the ontogeny for pattern processing was reproduce, then identify followed by extend. Related to task difficulty, Blackall (1975) also found that linear patterns were generally less difficult than matrix patterns. Sternberg (1973) found that his pattern tasks differed in difficulty, increasing in the following order: original learning, reverse shift, intradimensional shift, extradimensional shift (color and category), extradimensional shift (name), partial intradimensional shift and extradimensional shift (label). An intradimensional shift uses the same pattern but varying the elements within the same stimulus dimension. For example, a response to GREEN YELLOW GREEN YELLOW might be RED BLUE RED BLUE. An extadimensional shift uses the same pattern but varies elements outside the stimulus dimension. For example, a response to RED RED BLUE RED RED BLUE might be a sequence of pictures of Turtle Turtle Bike Turtle Turtle Bike.

Other variables which have been studied are socio-economic status as found by Bass (1975) to be influential and sex as found by Blackall (1975) to be only of minor impact.

The Prerequisites to Pattern Processing

The related literature attempts to offer several skills or aspects of behaviour which have been deemed as prerequisite for the ability to solve patterns. Since a large portion of these refer to Piagetian classifications, a brief overview of Piaget's relevant work will be given here.

The basis of Piaget's theory is the identification of four major phases of intellectual growth through which children pass in a necessarily sequential order. It has been stressed, however that while all children follow the same general pattern of transition from one stage to the next, they do so at an individual rate in terms of chronological age.

From the time a child is born until he is roughly two years old, the child's thinking is dependent upon the actions he performs on his environment. At first many of his actions are reflexive and uncoordinated, but during this period they begin to become coordinated. This period is known as the Sensori-Motor stage. From this Sensori-Motor stage, the child begins transition into a Pre-Operational stage. This period, lasting from approximately age two until age seven, includes the acquisition of language. With this medium the child is able to represent his world symbolically with words. As well, he is often given to representation through action, as can be seen when children play house, or pretend to be somebody else. The child's logic is, at this point, unidirectional. The child can realize cause and effect relationships, but cannot reverse this process to see the converse relationships.

Transition for the child begins at approximately seven, into the phase of intellectual growth known as Concrete Operations. This phase, which typically lasts four to five years, is characterized by the beginnings of logico-mathematical thought. The child can now reverse his thinking in terms of relationships. The classic mark of having arrived at the Concrete Operational stage of development is facility with the concept of conservation.

The Pre-Operational child will watch water poured from a stout glass into a tall, thin cylinder and will think the amount has changed, even though he saw none added, simply because it looks 'bigger'. However, the Concrete Operational child is aware that, even though it appears to be more, the process can be reversed to return to it's original state, therefore, the water must not have changed in quantity.

The Concrete Operational child manipulates what he perceives, through direct action upon it. Thus his thinking at the beginning of this stage depends on experience with physical objects and material. However, as he develops through this stage, he begins to generalize and thus becomes less dependent on the physical material.

Finally, at approximately age twelve, the child will acquire the ability to reason logically and abstractly. He can use his thought processes without physical objects or concrete examples. Thinking can operate hypothetically and deductively, and will develop in this mode through adulthood. This final stage of development is known as Formal Operations (Copeland, 1974).

A major structure of Piaget's by which thinking at the various stages is defined is that of an operation. Flavell clarifies Piaget's terminology: "any representational act which is an integral part of an organized network of related acts is an operation" (1963, p. 166). Piaget's operation of cognitive functioning is very much like the mathematical structure of a group. The mathematical group is a set of elements which possess the properties of closure, commutativity, associativity, reversibility and an identity element. Similarly the Piagetian operation must contain reversibility and an identity (Copeland, 1974). An operation "is thus the essence of knowledge; it is an interiorised action which modifies the object of knowledge" (Piaget, 1964, p. 8). For Piaget, the operation is central to thinking:

> Operational structures are what seem to me to constitute the basis of knowledge, the natural psychological reality, in terms of which we must understand the development of knowledge. And the central problem of development is to understand the formation, elaboration, organization and functioning of these structures (Piaget, 1964, p. 9).

Operational thinking is a major distinguishing factor in determining the child's transition from Pre-Operational thought to Concrete Operational thought.

> During all this second period of Pre-Operational representations, there are as yet no operations...In the absence of operational reversibility, there is no conservation of quantity... In a third stage the first operations appear, but I call these concrete operations because they operate on objects, and not yet on verbally expressed hypothesis (Piaget, 1964, p. 9).

Among the operations which Piaget identifies are conservation and classification.

Several of these operations have been hypothesized as being prerequisite for the ability to process patterns. Blackall (1975) hypothesized that conservation of number might be prerequisite for all pattern tasks, based on a significant correlation coefficient for conservation and pattern success. Bragman and Hardy (1982) cited that "one prerequisite seen for true pattern recognition is the ability to perform one-to-one correspondence" (p. 45). One-to-one correspondence is largely based on conservation of number. Sternberg (1975) saw that higher order classification skills were necessary to solve patterns which involved the sequencing of classes of objects. One-to-one correspondence, described by McKillip (1970) as block-to-block comparisons, seemed essential to perform single copying of patterns.

In addition to the above mentioned prerequisites, several other behaviours necessary for pattern processing have been found. Silvia (1977) saw that the ability to solve patterns which varied one attribute was prerequisite to the ability to solve patterns which varied two or three attributes. Simon and Kotovsky (1963) decided that a concept of same or equal was necessary to solve pattern problems. Klahr and Wallace (1970) substantiated this element and added another: "the ability to recognize 'sames' when they occur and the ability to keep track of position within two lists: the pattern and the problem" (p. 245). Visual discrimination has been seen by Sternberg (1975) as prerequisite to most patterning behaviours, and, for higher order classification patterns, knowledge of language labels is necessary. Again the ability to see sameness or differences was said to be necessary for pattern copying by McKillip (1970), and he noted that the ability to copy patterns is prerequisite to the ability to extend patterns. Scandura (1971) decided that "detecting most regularities depends, at least in part, on the prior acquisition of other information that relates specifically to the regularity...in question" (p. 16), and he gives primitive perceptual abilities as the prerequisite to most simple patterns.

This chapter has been devoted to a review of the literature regarding pattern processing. It has surveyed the information available on the abilities which are thought to be related to pattern processing, for example, copying of a sequence, pattern completion tasks, pattern recognition tasks and the imposition of a pattern upon unfamiliar stimuli. It has also surveyed the information available regarding the actual processing of patterns, and the existing attempts to explain how the human mind processes patterns. This review of the literature has also examined the many variables which have been seen to be influential in determining success at processing patterns. Specifically, the variables of age, developmental level, previous learning, mathematical achievement and intelligence of the subject, as well as various aspects of the actual pattern task have been identified. Finally, the literature review has attempted to sort the information into some of the prerequisites for pattern processing.

This study was designed in an attempt to answer some of the queries posed in the first chapter. A more detailed description of the sample of children, the design of the study, the instruments used and the ensuing analysis follows in chapter three.

CHAPTER III

DESIGN OF THE STUDY

It had been established earlier that there existed a need for research into the area of pattern processing at the early childhood level. Based on this need it was decided to design a study in order to examine the pattern processing abilities of several children at different developmental levels to see if success in patterning was variable depending on stage of intellectual development. As well, an examination of the errors committed by children at different stages of development was proposed in order to identify the existence of inherent pattern processing tendencies. As well, this examination would allow grouping of errors into identifiable error-types and perhaps shed light on additional characteristic tendencies at the given levels of development. With this framework in mind, instruments were constructed which would be useful in distinguishing children at various levels of development, and which would give some measure of the subjects' pattern processing abilities. To help refine these instruments, as well as to help identify the most suitable sample of subjects, it became necessary to conduct a pilot study.

The Pilot Study

The pilot study was undertaken in an attempt to refine the materials and methodology used in the administration of the various test items. As well, it was conducted to shed light on the performance at the various age/grade levels and hopefully point toward a target sample for the study. Test items were given to several children at the kindergarten, grade one, grade two and grade three levels. Based on this experience, some adjustments were made to the materials to be used, a protocal of instruction was decided upon and a target group was defined for the sample.

The Sample

The sample chosen for this study consisted of all of the children who are students of grade one and grade two at St. Columba's Primary School in Harbour Grace, Newfoundland. This group was not selected randomly, but rather was a purposive sample, chosen on the basis of it's suitability and accessibility. The children reside in communities from Spaniard's Bay, north to Harbour Grace.

Table 1 gives a description of the group with respect to age, sex and grade level.

Table 1

Distribution of Sample by Sex, Age and Grade Level

	Total Number	Male	Female	Mean Age
Grade One	46	27	19	83.5 s = 5.35
Grade Two	51	25	26	97.08 s = 4.04
Total	97	52	45	90.64 s = 8.27

The 97 children in the sample ranged in age from 77 months to 107 months, which coincided with the average transitional point between Pre-Operational and Concrete Operational thinking as defined by Piaget (Copeland, 1974) and as described earlier in this study. Of the 97 subjects, 46 were at the grade one level and 51 were at the grade two level. The mean age for the whole group was 90.64 months.

The Instruments

Two instruments were used in this study. The first consisted of a set of Piagetian type tasks and the second consisted of a set of pattern tasks.

The Piagetian Instrument

The Piagetian Instrument consisted of tasks in three categories: conservation of number, conservation of area and classification. In all there were ten tasks for each subject to complete. The materials used and the procedure is given in Appendix A, and the response sheet in Appendix B.

There were three tasks which were designed to measure conservation of number. In other words, they determined whether or not a child could comprehend that, if given equal numbers of some items, the numbers remained equal over any transformation provided none was added or taken away. The first of these tasks involved two sets of colored shells which provided an unprovoked situation (i.e., the shells did not naturally match one to another). The second task involved provoked correspondence by using cups and saucers which did seem to naturally match one to another. The third task demanded that the child realize that, while the same number of beads in a tall, thin cylinder looked like more than in a short, stout cylinder, the number remained the same.

There was one task on this instrument which measured conservation of area. This item was similar to the preceeding items, except that it was designed to check whether or not a child could understand that equal amounts of two-dimensional space do not change over a transformation which does not add to or take away from the area.

The next section was divided into three tasks which measured class inclusion and one which measured classification. Formanek and Gurian (1981) describe the question which class inclusion activities seek to answer as, "Is the child able to construct classes and subclasses (class hierarchy) using representational objects?" The class inclusion items on this instrument used real objects (beads) as well as pictures of animals and pictures of children.

The final task on this instrument was classification. For this task the child was asked to sort a set of attribute blocks into groups of things which belonged together. On this task, the children were measured on their ability to identify and classify the blocks by each of the three attributes they exhibited: shape, color and size.

The Pattern Instrument

The pattern instrument consisted of six tasks. In each of these, the child was shown a linear arrangement of blocks which were identical in every respect except color. The blocks were arranged so that they contained a definite pattern, with two periods given. The child was required to study the series and choose blocks from a given pile of the colored blocks so as to continue the given pattern. The items are described in Appendix C and the response sheet is given in Appendix D.

Administering the Tests

Both of the instruments in this study were administered during the months of May and June of 1984. The Piagetian tasks were administered on an individual basis, by the investigator, to distinguish between Pre-Operational, Transitional and Concrete Operational children. The material was presented on a low table with the subject seated directly opposite and across the table from the examiner. Subjects were given oral directions and their responses, both oral and manual were coded according to the given criterion and recorded on the appropriate Response Record Sheet. A total score was then assigned to each subject on the basis of these codes.

The pattern tasks were administered to subjects who qualified as Pre-Operational or Concrete Operational based on the results of the Piagetian instrument. These tasks were administered in the same environment as the Piagetian tasks and in much the same manner. The exact student response to each pattern was recorded to a maximum of two more of the defined period. The responses were later coded according to set criteria and results tabulated for analysis.

Analysis of the Data

Because the sample used was a purposive one; that is the subjects were selected on their attributes rather than randomly, the analysis of the data will follow a descriptive mode. Nonparametric statistics only will be used and statements of existing differences will not be in terms of statistically significant differences. As described in the "Limitations of the Study", this is a case study of a small group of children. No inference will be made to a larger population, however existing trends will be noted and the possibility of broader applications of these will be hypothesized.

The basis for this study was outlined in a set of seven questions. In an attempt to answer these questions, the data was analyzed as follows.

Question #1. Is there any difference between the distribution of children at the Pre-Operational, the Transitional and the Concrete Operational stages at the grade one level and this distribution at the grade two level?

To answer this question, the children were sorted into their respective grade levels. When this had been done, each child within each grade level was assigned to one of the three defined Piagetian groups based on the following criterion: seven or more "correct unassisted" responses denoted Concrete Operational, seven or more "incorrect" responses denoted Pre-Operational and those who did not qualify in either of these were classified as Transitional. The percentage of subjects at each Piagetian level was compared across the two grade levels to determine whether or not they differed and if so, by how much.

Question #2. Is there any difference between the mean ages of the Pre-Operational, the Transitional and the Concrete Operational groups?

To answer this question, all of the subjects were sorted into the three Piagetian groups, irrespective of grade level. For each group, the mean age was then calculated. These mean ages were then compared to see if and by how much they differed. As well, the standard deviations were calculated for comparison.

Question #3. Is there any difference in the rate of success on the patterns tasks between the Pre-Operational group and the Concrete Operational group?

For this question, the patterns test, which was administered to the Pre-Operational and Concrete Operational groups only, was checked against the key (in Appendix E) and the total number correct tabulated for each student. Then the mean score, range and standard deviation was calculated for each of the two groups and these were compared to see what differences existed.

Question #4. Does the Pre-Operational group differ from the Concrete Operational group in the proportion of subjects who, in an erroneous response, imposed a pattern?

To begin this analysis, it was necessary to set up some criterion by which to decide whether or not a pattern had been imposed. A period had been defined earlier as a linear arrangement of objects in a defined order, capable of being reproduced. Thus it was decided to use two repetitions of a period as the criterion for pattern imposition. If, in the child's erroneous response, it was possible to identify an uninterrupted set of two repetitions of any period, then it was decided that the subject had imposed a pattern.

Once this had been established, the answers of all of the children on the patterns tasks which had been judged as incorrect from the analysis for question #3, were measured against this criterion. The percentage of children in each group who fit this criterion 50% or more of the time were compared to see if one group showed more pattern imposition than the other.

Question #5. Is there any difference between the Pre-Operational group and the Concrete Operational group in the proportion of perseveration-type errors that they make?

Perseveration was defined earlier as continuation of a string of one color. Based on this, a child was perseverating if he or she repeated a color more often than was required by the stimulus pattern. For example in the given pattern BLUE YELLOW YELLOW BLUE YELLOW YELLOW, the child would be perseverating if he or she continued the string of YELLOW instead of staring with a BLUE. With this in mind, all of the children's responses which had been judged incorrect for question #3 were examined again to determine whether or not tendencies to perserverate were evident. The percentage of children in each group who perseverated on 50% or more of their errors were compared to determine whether one group displayed this tendency more than the other group.

Question #6. Is there any difference between the Pre-Operational group and the Concrete Operational group in the proportion of alternation-type errors that they make?

Earlier in this study, alternation had been defined as alternation of two elements of the period. Thus a child was alternating if, in response to the pattern BLUE YELLOW YELLOW BLUE YELLOW YELLOW he or she responded BLUE YELLOW BLUE YELLOW. If a subject alternated two colors inappropriately then this was labelled an alternation-type error. All of the children's erroneous responses, determined for question #3, were examined to determine whether or not alternation-type errors were present. The percentage of children in each group who alternated on 50% or more of their errors were compared to determine which, if either group tended more often to alternate in error.

Question #7. Does the Pre-Operational group differ from the Concrete Operational group in the item on the patterns instrument on which the largest number of errors were made?

For this question it was necessary to determine, for each of the two groups, the item which had elicited an incorrect response most often. To find this item, within each group one point was assigned to any item to which a subject had responded incorrectly. When a total for each item was found for each of the two groups, the item with the largest total number of errors for the Pre-Operational group was compared to the item with the largest total for the Concrete Operational group to determine whether or not it was the same item.

The details of this analysis are contained in chapter four, in an attempt to provide answers to the foregoing questions.

CHAPTER IV

ANALYSIS OF THE DATA

The previous section discussed how the data were to be collected and analyzed. This was accomplished according to these guidelines and the information is now presented within the context of the original seven questions.

Question #1. Is there any difference between the distribution of children at the Pre-Operational, the Transitional and the Concrete Operational stages at the grade one level and this distribution at the grade two level?

The children were first sorted into their respective grade levels. This sorting showed 46 children at the grade one level and 51 children at the grade two level. The children were assigned to one of three defined Piagetian-type groups based on the given criterion: seven or more "incorrect" responses denoted Pre-Operational, seven or more "correct unassisted" responses denoted Concrete Operational and any child who did not qualify in either of these was classified as Transitional. The total numbers for each of these three groups were 27 Pre-Operational, 43 Transitional and 27 Concrete Operational. The percentage of subjects at each grade level for each of the three levels was calculated. The results are displayed in Table 2. Comparing across grade levels, 15 of the

Table 2

Distribution of Grade Levels by Piagetian Stage

	Grade One	Grade Two	Total
Pre-Operational	15 (55.56%)	12 (44.44%)	27
Transitional	21 (48.84%)	22 (51.16%)	43
Concrete Operational	10 (37.04%)	17 (62.96%)	27

Pre-Operational children were grade one's and 12 of the Pre-Operational children were grade two's. On a percentage basis this shows that 55.56% of the Pre-Operational children were grade one's and 44.44% of the Pre-Operational children were grade two's. For the Transitional level it was found that 21 of the 43 were grade one's. This was 48.84% of the Transitional group. Twenty-two of these 43 were grade two's which accounted for 51.16% of the group. The remaining 27 at the Concrete Operational level were divided with 10 at the grade one level and 17 at the grade two level. This represented 37.04% at grade one and 62.96% at grade two.

Another way of looking at these data is presented in Table 3.

Table 3

Distribution of Piagetian Stage by Grade Level

	Grade One	Grade Two
Pre-Operational	15 (32.61%)	12 (23.53%)
Transitional	21 (45.65%)	22 (43.14%)
Concrete Operational	10 (21.74%)	17 (33.33%)
Total	46	51

Here, the data are presented as proportions of children at each grade level. At the grade one level, 15 of the 46 were Pre-Operational, 21 of the 46 were Transitional and 10 of the 46 were Concrete Operational. In other words 32.61% of the grade one subjects were Pre-Operational, 45.65% of the grade one's were Transitional and 21.74% of the grade one's were Concrete Operational. At the grade two level, 12 of the children were Pre-Operational, 22 of the children were Transitional and 17 of the children were Concrete Operational. These numbers represent 23.53% of the grade two subjects at the Pre-Operational stage, 43.14% of the grade two subjects at the Transitional stage and 33.33% at the Concrete Operational stage.

The original question that this analysis sought to satisfy asked whether or not the Piagetian distribution was different for each grade level. The information in Table 3 indicated that indeed the percentages at each Piagetian stage were different for the two grades. The grade one's showed 32.61% at the Pre-Operational stage while the grade two's showed only 23.53% at that stage. At the Concrete Operational stage the grade two's had the largest percentage at 33.33% over 21.74% for the grade one's. At the transitional stage the percentages were closer with 45.65% of the grade one's and 43.14% of the grade two's.

The most prominent differences between the Piagetian distributions were seen at the extremities of the Piagetian scale as opposed to the central Transitional stage which held the largest percentage for both groups. The grade one's showed the second largest sub-group at the Pre-Operational stage while the grade two's showed the second largest sub-group at the Concrete Operational stage. Consequently, the stage with the smallest proportion for grade one was the Concrete Operational stage and the stage with the smallest proportion for grade two was the Pre-Operational stage.

These findings seemed to imply that the children's thinking at grade one and two levels was very different. The bulk of the grade one children were either non-conservers or were just beginning to conserve, while the bulk of the grade two children conserved either partially or totally.

This aroused many questions regarding the role of instruction in the child's intellectual development. In the past it had generally been thought that development was largely a process of maturation, however this point has come under some debate in recent years. The results in this study seemed to indicate that the grade two children conserved more than the grade one children. The grade two children will have had learning experiences that the grade one children will not, however the grade two children were also older on the average than the grade one's. Therefore, whether the developmental difference might be due to schooling or maturation only becomes evident when one examines the Piagetian distribution in terms of mean ages, as is done for the next question.

Thus, in conclusion, the data seemed to imply that Piagetian distribution does differ between grade one and grade two.

Question #2. Is there any difference between the mean ages of the Pre-Operational, the Transitional and the Concrete Operational groups?

As outlined earlier, the procedure here involved sorting the subjects into the three Piagetian stages irrespective of grade level. Once this had been done, the mean age was calculated for each of the three groups. As well, the standard deviation for each group was tabulated.

This information is presented in Table 4.

Table 4

Mean Ages for Piagetian Stages

	Mean Age	Standard Deviation
Pre-Operational	89.85 months (or 7 yrs., 6 months)	8.38
Transitional	90.86 months (or 7 yrs., 7 months)	9.15
Concrete Operational	91.52 months (or 7 yrs., 8 months)	.65

It was found that the age difference between the Pre-Operational and Transitional groups was 1.01 months and the age difference between the Transitional and Concrete Operational groups was .66 months. The difference in ages from the Pre-Operational group to the Concrete Operational group was 1.67 months.

This data seemed to lend support to the idea that age may not play a large part in determining level of intellectual development. In the framework of Piagetian research, the approximate age of 7 or 8 years was usually cited as the point at which a child becomes fully operational in his thinking (Copeland, 1974; Inhelder and Piaget, 1964; Piaget, 1952). However, the data gathered in this experiment showed that approximately 7 1/2 years was the mean age of all three stages of development. Couple this with the implications from the first question and it seems reasonable to assume that, for this sample, learning experiences were of more importance than age in determining developmental level.

Thus, it was concluded that there was a difference in the three mean ages but it was noted that the difference may be small enough to be called insignificant in this study.

Question #3. Is there any difference in the rate of success on the patterns tasks between the Pre-Operational group and the Concrete Operational group?

This portion of the study dealt with only the Pre-Operational and the Concrete Operational groups. The patterns instrument was administered and was checked against the key. Each of the children was then given a score indicating the number correct out of six items. Within each group the mean number correct was tabulated as well as the standard deviation. The mean number correct was also translated into a percentage. This information is presented in Table 5.

Table 5

Mean Scores on Patterns Test for Two Piagetian Groups

	Mean Score	Standard Deviation
Pre-operational n = 27	4.04 (67.33%)	1.698
Concrete Operational n = 27	5.33 (88.83%)	.877

The 27 Pre-Operational children made a total of 53 errors while the 27 Concrete Operational children made a total of only 18 errors. From the data it was determined that the mean score for the Pre-Operational group was 4.04 while the mean score for the Concrete Operational group was 5.33. This amounts to a difference of 1.29.

The score was based on only six items, therefore it may or may not be misleading to transform the means to percentages, however these figures were reported as an alternative way to examine these data. Using this method it was found that the mean percentage for the Pre-Operational group was 67.33% correct while the mean percentage for the Concrete Operational group was 88.83% correct, a difference of 21.50%.

The groups differed also on the range of number correct. The Concrete Operational group's scores ranged from a low of three correct to a high of six correct. The

Pre-Operational group's scores, on the other hand, ranged from a low of 0 correct to a high of six correct. A distribution of the number of students at each of the seven possible total scores is illustrated in figure 1.

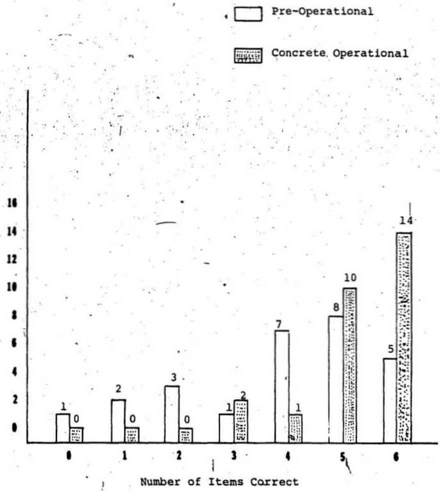

Figure 1. Frequency Distribution of Total Number Correct on Pattern Tasks for Pre-Operational and Concrete Operational Children

Figure one seemed to indicate that the two developmental levels differed in terms of their ability to process patterns. The Concrete Operational group seemed to process patterns in a way more closely resembling how adults process them. For some reason, the Pre-Operational children either could not identify the pattern, which was presented, or could identify it but could not continue it, to the same degree as the Concrete Operational children could. The implications of this situation are many, and will be discussed in the fifth chapter. However it can be said here that the information seems to lend itself to the notion that operational thinking skills, as tested in the Piagetian instrument, may be prerequisite to the ability to process patterns.

Thus it would appear, in answer to the question posed, that the groups did differ in the rate of success on the patterns tasks with the Concrete Operational group having a higher mean score than the Pre-Operational group.

Question #4. Does the Pre-Operational group differ from the Concrete Operational group in the item on the patterns instrument on which the largest number of errors were made?

Earlier in this study, criterion had been established to determine whether or not a subject's incorrect response showed evidence that he or she had attempted to impose some pattern. All of the subjects' incorrect responses were examined in this light to distinguish between those who did and did not impose a pattern. The number of children who had displayed this pattern imposition tendency on 50% or more of their erroneous responses was sought for each group. These numbers and the corresponding percentages are given in Table 6.

Table 6

Pattern Imposition Tendencies in Erroneous Responses for Two Piagetian Groups

	Number who did not show pattern imposition	Number who showed pattern imposition	Total number with erroneous responses
Pre-Operational	4 (18.18%)	18 (81.82%)	22
Concrete Operational	3 (23.08%)	10 (76.92%)	13

The first significant piece of information which was shown in this table was that more Pre-Operational children had incorrect responses (22) than did Concrete Operational children (13). Of the 22 Pre-Operational children who had erroneous responses, 18 of them imposed a pattern 50% or more of the time. This represented 81.82% of that sub-group. Ten of the 13 Concrete Operational children who had incorrect responses showed pattern imposition and this represented 76.92% of that sub-group.

This data shows that both groups showed the tendency to impose a pattern to a fairly high degree. This was an interesting finding, for it indicated that, when the children did not see the pattern given, they tended to make up one of their own, and that if they saw the existing pattern but had difficulty in extending it, their extensions showed the tendency to impose some form of a pattern. In other words, even the students at the lowest level of development could organize stimulus information in a regular, logical fashion.

The fact that the Pre-Operational subjects made more errors might have given more reliability to their percentage. In any case, while both groups imposed a pattern often, the actual percentages favored the Pre-Operational group as those who imposed a pattern most often.

Question #5. Is there any difference between the Pre-Operational group and the Concrete Operational group in the proportion of perseveration-type errors that they make?

It was decided earlier that a child would have been perseverating if he or she had repeated one color in a string more often than was required by the given pattern. All of the childrens' incorrect responses were examined to determine the proportion of children in each group who had perseverated on 50% or more of their incorrect responses. The numbers of children found in each group as well as the corresponding percentages are given in Table 7.

Table 7

Perseveration Tendencies in Erroneous Responses for Two Piagetian Groups

	Number who did not show perseveration	Number who showed perseveration	Total number with erroneous responses
Pre-Operational	18 (81.82%)	4 (18.18%)	22
Concrete Operational	12 (92.31%)	1 (7.69%)	13

Again, the fact that the Pre-Operational children made more errors may have had some influence over the percentages presented in Table 7. Also, the Concrete Operational children who made errors tended to make fewer of them and so it may or may not have been valid to state with certainty that a subject did not show perseveration tendencies when such an assumption was based on only one error. The Pre-Operational children who made errors tended to make more of them, thus one would have been able to state with more certainty, for example, that a subject did not perseverate when he did not on four of five errors.

From the data, it is obvious that the greater proportion of students in both groups did not show perseveration tendencies. It is of some interest that neither group perseverated to any great extent. This may indicate that perseveration is a tendency more characteristic of a learning disability or of mental retardation than of a lower level of intellectual development.

In any case, at four of 22 or 18.18% perseverating, the Pre-Operational group did seem more inclined toward the tendency to perseverate than did the Concrete Operational group, who had one of 13 representing 7.69%.

Question #6. Is there any difference between the Pre-Operational group and the Concrete Operational group in the proportion of alternation-type errors that they make?

Alternation-type errors had been earlier defined as an error which involved alternating two colors inappropriately or more than was required by the stimulus pattern. Once again it was necessary to examine the subjects' erroneous responses to find the number of subjects in each group who had committed this alternating kind of mistake on 50% or more of their incorrect responses. The total numbers who made errors were the same as for the previous questions; 22 Pre-Operational and 13 Concrete Operational. The proportion of these who alternated and who did not alternate, as well as the related percentages are given in Table 8.

Table 8

Alternation Tendencies in Erroneous Responses for two Piagetian Groups

	Number who did not show alternation	Number who showed alternation	Total numbers with erroneous responses
Pre-Operational	12 (54.55%)	10 (45.45%)	22
Concrete Operational	12 (92.31%)	1 (7.69%)	13

Again, more of the Pre-Operational children made errors and those who did make errors tended to make more of them than the Concrete Operational children, who typically made only one error. Therefore, as in the previous analysis, one can question the validity of these percentages.

These data seemed to show more substantial differences in the percentage of each group who showed alternation tendencies than did the data on perseveration. In this instance 10 of the 22 Pre-Operational children showed alternating tendencies in 50% or more of their errors. This accounted for 45.45% of that sub-group as opposed to 54.55% who did not. This was compared with one of the 13 Concrete Operational subjects who alternated and 12 of the 13 who did not. This represented 7.69% alternating as opposed to 92.31% not alternating.

While the Pre-Operational group was near the halfway point in terms of those alternating and those not alternating, the Concrete Operational group showed a strong tendency toward not alternating. This indicates that alternation may be a stronger tendency in general than perseveration. It also seems to indicate that thinking at the two levels of development differed with respect to this tendency. This tendency to alternate might even be a characteristic of many children at the Pre-Operational stage of development and the shift away from that inclination might be characteristic of the move to Concrete Operational thinking.

In summary, it was concluded that there was a difference in the proportion of subjects who displayed alternation-type errors, with the Pre-Operational group committing these errors much more frequently.

Question #7. Does the Pre-Operational group differ from the Concrete Operational group in the item on the patterns instrument on which the largest number of errors were made?

The data for this question were collected from the 22 Pre-Operational subjects and the 13 Concrete Operational subjects who had made incorrect responses. The information sought involved the particular item on which errors had occurred most frequently for each group. To determine this, the frequency of errors for each group on each of the six patterning items was tabulated and are presented in Figure 2.

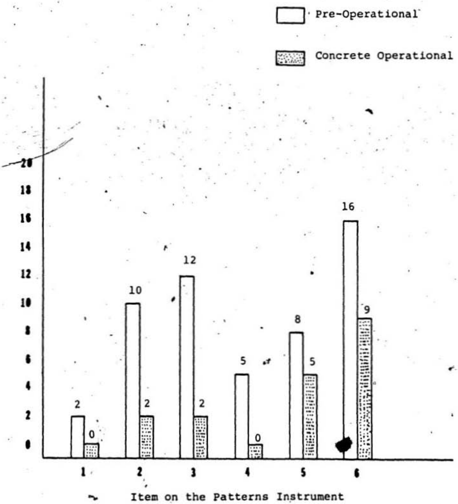

Figure 2. Frequency of Errors on Each Pattern Item For Two Piagetian Groups

Figure 2 illustrated that the Pre-Operational group made errors on all six items, while the Concrete Operational group made no errors on Item #1 and Item #4. Also it was obvious that the Pre-Operational children made more errors than the Concrete Operational children on all items.

The question here dealt with the item which caused the most errors for each group. Again Figure 2 showed that the Pre-Operational group made most of their errors on Item #6. The Concrete Operational group also made most of their errors on Item #6. Thus the question is answered by stating that there was no difference between the two groups on the item which caused the most errors.

As additional information the percentage of errors on each item for each group was calculated. These percentages were tabulated in an effort to establish the relative difficulty of each item for the two groups. These results are presented in Table 9.

Table 9

Percentage of Errors on Pattern Items
for Two Piagetian Groups

	Pre-Operational	Concrete Operational
Item #1	2 (4%)	0 (0%)
Item #2	10 (19%)	2 (11%)
Item #3	12 (23%)	2 (11%)
Item #4	5 (9%)	0 (0%)
Item #5	8 (15%)	5 (28%)
Item #6	16 (30%)	9 (50%)
Total	53	18

This information enabled a hierarchy of difficulty to be organized for each group. The rank order of difficulty from most difficult to least, based on these percentages, is presented in Table 10.

Table 10

Order of Difficulty of Pattern Items for
Pre-Operational and Concrete Operational Groups

	Pre-Operational	Concrete Operational
Most Difficult	Item #6 (30%)	Item #6 (50%)
	Item #3 (23%)	Item #5 (28%)
	Item #2 (19%)	Item #2 (11%)
	Item #5 (15%)	Item #3 (11%)
	Item #4 (9%)	Item #1 (0%)
Least Difficult	Item #1 (4%)	Item #4 (0%)

In addition to the fact that Item #6 was most difficult for both groups, it was apparent that Items #1 and #4 were least difficult for both groups. The largest difference in difficulty involved Item #5 which was the second most difficult for the Concrete Operational group, accounting for 28% of their errors, while it was less difficult for the Pre-Operational group, accounting for 15% of their errors. Again, interpretation of these percentages must be done in light of the fact that there was a small number of errors from the Concrete Operational group as compared with the Pre-Operational group.

Also, while Item #6 was most difficult for both groups, it represented the largest discrepency between groups in the percentage of errors it represented. Item #6 represented 50% of all errors for the Concrete Operational group while it represented only 30% of all errors for the Pre-Operational group. This may be explained by the fact that, in general, the Pre-Operational children's mistakes were spread more evenly among the six items than were the Concrete Operational children's errors, which were clustered around Items #5 and #6.

Summary

The findings from the analysis of the data were not thought to be definitive, however some interesting observations were made. These are summarized as follows:

(1) The grade two children were generally higher on the Piagetian developmental scale than were grade one children.

(2) Age did not seem to play a part in determining the childrens' level of intellectual development.

(3) Concrete Operational children tended to process patterns more successfully than Pre-Operational children.

(4) Nearly all subjects tended to impose their own pattern in an incorrect response.

(5) Perseveration was not a strong tendency in the errors of either group, however it was slighly more frequent in the Pre-Operational group.

(6) Alternation seemed to be a stronger error tendency than perseveration, and was a fairly common error type of the Pre-Operational group, but not of the Concrete Operational group.

(7) Both groups seemed to find the same item the most difficult, but differed on the second most difficult. They also agreed on the least difficult item.

The remainder of this study will be devoted to a summary of the results and a discussion of the findings and their implications for mathematics education in early childhood.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of the foregoing study was to investigate the pattern processing abilities of young children. It was the intent of the investigation to shed some light on how well young children could detect and extend linear patterns, to try and determine whether or not operational thinking as defined by Piaget was prerequisite to the ability to solve patterns and to see how operational thinking affected trends toward certain error-types. The nature of a case study logically precludes the ability to generalize any findings, thus this study has not made any attempts at inferring to a larger group and any results found were not thought to be definitive. Instead, it was thought that this kind of study would produce valuable information on how children think and would illustrate trends which existed in the area of pattern recognition. Then, from these data, questions, ideas and hypotheses concerning young children in general which were raised could be explored in future research.

The study sought to answer a set of seven specific questions concerning young childrens' thinking and specifically about pattern processing. A sample of 98 children was purposively selected. The subjects were all at the grade one and two level and of mean age 90.64 months. These children were tested first to determine their level of operational thought, and then again to determine their pattern processing abilities. A summary of the findings is given below:

Question #1. Is there any difference between the distribution of children at the Pre-Operational, the Transitional and the Concrete Operational stages at the grade one level and this distribution at the grade two level?

It was found that the grade two children were generally higher on the Piagetian developmental scale than were the grade one children. In other words, there were mostly grade two children among the Concrete Operational thinkers and mostly grade ones among the Pre-Operational thinkers. The Transitional group was a fairly even mixture of both grade levels.

Question #2. Is there any difference between the mean ages of the Pre-Operational, the Transitional and the Concrete Operational groups?

The mean ages of the three developmental levels were separated each by only one month. Therefore it was concluded that age did not seem to play a part in determining the child's level of intellectual development.

Question #3. Is there any difference in the rate of success on the patterns tasks between the Pre-Operational group and the Concrete Operational group?

More Pre-Operational children made errors and those who did, tended to make more of them than did Concrete Operational children. On the whole, Concrete Operational children tended to process patterns more successfully than Pre-Operational children.

Question #4. Does the Pre-Operational group differ from the Concrete Operational group in the proportion of subjects who, in an erroneous response, imposed a pattern?

The result of this analysis showed that in general, both groups showed pattern imposition tendencies. The difference between the groups was slight (a 4.9% difference), although the Pre-Operational group imposed a pattern more often.

Question #5. Is there any difference between the Pre-Operational group and the Concrete Operational group in the proportion of perseveration-type errors that they make?

Perseveration seemed not to be a strong tendency for either group in the study, however it was slightly more frequent among errors made by Pre-Operational children.

Question #6. Is there any difference between the Pre-Operational group and the Concrete Operational group in the proportion of alternation-type errors that they make?

Alternation seemed to be a stronger error tendency than perseveration. It was more prevalent among the

Pre-Operational group than the Concrete Operational group.

Question #7. Does the Pre-Operational group differ from the Concrete Operational group in the item on the patterns instrument on which the largest number of errors were made?

Both groups seemed to agree that Item #6 caused the most errors. Both groups also seemed to agree that Items #1 and #4 were least difficult. The largest difference between groups occurred on Item #5 which was second most difficult for the Concrete Operational group but fourth most difficult for the Pre-Operational group.

Discussion

The original sample of 98 children was measured on their level of operational thinking, and were each classified as Pre-Operational, Transitional or Concrete Operational. When this had been accomplished, two variables were inserted: grade level and age. Questions were posed regarding whether or not grade level influenced the Piagetian distribution and, whether or not the mean age varied for the three levels of operational thinking. It was concluded that, while the mean ages for the three groups was varied by only one month each, the Piagetian distribution was very different when compared across grade levels. In other words, a younger child did not have any greater chance than an older child, to be classified as Pre-Operational.

However, a child at a lower grade level did seem to be pre-disposed to being Pre-Operational or Transitional.

This finding raised questions which have been debated since Piaget's research first surfaced. The debate centers around the issue of what causes intellectual development to occur, maturation or experience. There are those, like Piaget himself, who believe that intellectual maturation is largely not a product of instruction rather, "the notion of conservation is gradually constructed by means of an intellectual mechanism" (Piaget, 1952, p. 4). On the other hand, many experiments have been conducted which try to dispel this notion. Typically, these attempt to train the child in the various conservation experiences necessary for operational thought, and then apply the Piagetian tasks to show that the child who was a non-conserver prior to the experiment, has now been taught to conserve. "Although many individual studies failed to demonstrate significant training effects, almost every type of training procedure has been able to accelerate the acquisition of logical operations" (Carpenter, 1980, p. 159).

This is a moot point, however results of Questions #1 and #2 in this study seemed to say that for these children more important than age, was experience, as measured by schooling, in determining the child's level of operational thinking.

When the children had been sorted into their respective Piagetian groups, and the variables of age and grade level examined, the patterns instrument was administered to the Pre-Operational and the Concrete Operational groups. This instrument consisted of six linear patterns which the child was asked to extend. Of course, to extend the pattern successfully, the child had to be able to detect the rule in the given information. This investigation sought first to determine whether or not there existed any difference in rate of success between the two groups. It was hoped that, by such an investigation, some insight might be obtained as to whether or not operational thinking was a necessary prerequisite to pattern processing abilities. The number correct for each child was determined and a mean score for each of the two groups was calculated. These means allowed comparison in order to determine which group was generally more successful.

The analysis of the data showed that the Concrete Operational group showed a slightly higher degree of success than did the Pre-Operational group. The fact that there were only six items on which to base scores made interpretation of the means somewhat difficult. In terms of mean number correct, the Concrete Operational group obtained 5.33 as compared with a mean of 4.04 for the Pre-Operational group. In terms of mean percentage correct, the Concrete Operational group obtained 88.83% and the Pre-Operational group 67.33%.

In any case, it did seem evident that the Concrete Operational children solved patterns differently, perhaps more successfully than Pre-Operational children. This lead to speculation about the prerequisites for pattern processing. It might be that conservation of number, conservation of area, clas inclusion or classification, or the total of all of these are prerequisite to the ability to solve patterns. This lends support to Blackall's (1975) finding that there was a positive correlation between conservation of area and patterning success on most of her patterns. Interestingly, enough, she found also that conservation of number did not significantly correlate with success on any of the pattern tasks. Again these results are comparable to this or any other study only to the extent that the pattern tasks are comparable. In this study, no attempt was made to correlate the patterning success with individual items on the Piagetian instruments. Therefore conclusions can only be drawn from the Piagetian instrument as a whole.

Also it was not clear, what part of the process the Pre-Operational children had difficulty with. It might have been that they could in fact have seen and identified the pattern but experienced difficulty in the act of extension. Or it is possible that those children may not have been successful at detecting the pattern which existed.

If the former situation were the case, one might attribute this to several possible causes. One cause might have been the child's possible tendency toward impulsivity.

Impulsivity is exhibited by children who "are very quick to answer questions but often given irrelevant responses" (Bley and Thornton, 1981, p. 17). Indeed it was noticed several times through the course of the investigation, that some subjects were responding rather quickly and apparantly without a great deal of thought.

On the other hand, if it was true that the children were not successful at detecting the given pattern, this situation lends itself to an explanation in terms of Piagetian structures. It seems very doubtful that the children made any number of absolutely random responses. Indeed the analysis in chapter four showed that, in an erroneous response, the children imposed some type of pattern most of the time. Quite often during the course of the investigation, it was noticed that the child would repeat most of the given period but would consistently omit one or two items. For example, if asked to extend RED BLUE YELLOW RED BLUE YELLOW, they might respond with RED BLUE RED BLUE RED BLUE. In such an instance the child was focusing on part of the sequence or on one aspect of it and this focus may have blocked out the other elements in the pattern.

Such a behaviour seems very much like the Piagetian idea of centration. Centration is described as the "inability to hold in mind more than one relationship at a time, and the tendency to 'center' on one dimension" (Lovell, 1971, p. 7). Centration has been shown to be characteristic of the Pre-Operational child, thus this would seem to be a possible explanation for the lesser degree of success in processing patterns experienced by the Pre-Operational children. Further research could perhaps pinpoint the type of difficulty more accurately.

Question #4 in the study looked at how the subjects responded when they were unable to solve the pattern correctly, to see whether or not they tended to impose a pattern or not. The results clearly showed that both groups did impose a pattern fairly often. This finding substantiates the conclusions drawn by Frith (1970) that young normal and autistic children did seem to have a propensity to impose a pattern, even when it was not the appropriate one.

This seems to be saying something very important about the intellectual workings of young children; that Pre-Operational children and Concrete Operational children seem to exhibit some degree of logical, organized reasoning. Although they did not see or impose the same structure that an adult might, they did impose order. The fact that patterning skills had, for all intents and purposes not been taught to these subjects seems to suggest that this type of logical, inductive reasoning might be inherent in the child. They seem innately capable of structuring their surroundings regardless of age, level of development or instruction. The difference made by development seems only to "fine-tune" these already existing capacities.

It is an interesting thought that pattern processing might be an innate ability. Indeed, the ability to extract rules, and apply them to new situations seems to be at the very heart of the learning process. If we could not apply those skills which we have acquired, re-learning would have to take place in each new situation that we find. Klahr and Wallace agree that "the ability to detect environmental regularities is a cognitive skill essential for survival" (1970, p. 243). Further research might indicate whether this ability exists at lower age levels as well.

A further analysis of the errors in this study was undertaken, to distinguish two specific error types, and to determine the relative frequency of each. The first error type was called perseveration. "Students afflicted with perseveration get into patterns of behaviour and persistently repeat the pattern on every activity they face over a short period of time" (Thornton, Tucker, Dossey and Bazik, 1983, p. 48). A perseveration-type error would typically be extension of one color in the pattern rather than the whole period.

Perseveration has been shown to be a characteristic associated with learning disabilities (Thornton, et al., 1983; Bley and Thornton, 1981). Frith (1970) also showed perseveration to be a characteristic tendency of his autistic subjects. Interestingly, though, this trait has also been attributed to young children. Gerjuoy and Winters (1968) described the tendency to perseverate as typical of the young child. At approximately age 4 or 5 years, this tendency diminishes and is replaced by the tendency to alternate. It is unknown whether or not another study has been done which compares the tendency to alternate in groups of differing intellectual developmental levels.

This study may lend support to all of these notions of perseveration, simply by the fact that it was such a rare response. Indeed, the percentage of subjects which might have been learning disabled would have been very low if this was a representative sample. Also, the subjects were all older than the age suggested by Gerjuoy and Winters (1968) as the age at which perseveration tendencies diminish. Therefore, because a very small number of these students, perseverated, it is possible that perseveration is related to learning disabilities and to the under five age group.

Whether or not the findings show a preference for one of the two developmental stages is not clear. It was found that the Pre-Operational group showed evidence of perseveration on four respones, while the Concrete Operational group showed this on only one. Bearing in mind the small number of erroneous responses in the Concrete Operational group, this translates to 18.18% of the Pre-Operational group's erroneous responses and 7.69% of the Concrete Operational group's erroneous responses. These results do seem to show the Pre-Operational group as perseverating more often, however more research with larger samples of items might shed more light on this area.

The second error type examined was alternation. This, as the name implies, involved simple alternation of two colors where it was inappropriate to do so. This error type was more prominent in general than was perseveration. Also, this error type seemed to be much more successful in differentiating the two developmental stages than did the previous error type. The Pre-Operational group showed 10 alternating errors while the Concrete Operational group showed only one. The percentages, while interpreted cautiously, show that 45.45% of all errors of the Pre-Operatinal group were alternating while only 7.69% of the errors of the Concrete Operational group were alternating.

This finding does not support Gerjuoy and Winters' (1968) claim that the tendency to alternate begins at about 5 years of age. These results show that the tendency to alternate seems to be not so much age related as it is linked to operational thought. It was shown earlier that the two groups have very similar mean ages, but yet one group alternated in error more than the other. Again, further research with children who were of different age levels within different developmental levels might give more information regarding these indications.

The final point brought out by this study was the attempt to compare a hierarchy of difficulty of these pattern tasks for each group. The results showed that Item #6 was the most difficult for both groups. Recall that Item

#6 was as follows: GREEN RED GREEN GREEN GREEN RED GREEN GREEN. The most common mistake in this item for both groups seemed to be to begin the response with RED instead of GREEN. It was as if the subjects were trying to shorten the period to RED GREEN GREEN. Perhaps the difficulty with this item was brought about by the fact that the first and last element in this period are the same color: GREEN. In fact this explanation seems very plausible considering that this was the only item on the instrument with first and last elements identical.

If this theory was correct, then the strategy suggested by Klahr and Wallace (1970) of backward scanning might apply. If the child scanned from right to left, the red block might have caught his or her attention, then continuing left over several more green blocks, he might be again attracted by the other red. Thus the red might become the focal point and hence, the first element in his extension. Also, or possibly in conjunction with this model, the cognitive function of centration might also apply, in that the child centers on the red block and cannot keep in mind the number of green blocks before and after the red block. More pattern items and ones of various sequences might enable future research to offer a more definitive explanation for the difficulty in Item #6.

The least difficult item overall appeared to be Item #1, which accounted for only 4% of the Pre-Operational groups' errors and 0% of the Concrete Operational groups' errors. Item #1 was as follows: GREEN YELLOW GREEN YELLOW. The tendency to alternate on behalf of both groups regardless of the stimulus pattern might account for the relative ease with which this item was solved.

A look at the most difficult and least difficult items provides an interesting finding with regard to the variables associated with pattern processing. Since both items used only two colors, it might be concluded that the number of colors is not a factor in determining pattern difficulty. However, since the more difficult item had a longer period, it might be assumed that period length is of some importance in determining pattern difficulty. This idea supports Simon and Kotovsky's (1963) inference that length of pattern rule influenced difficulty and Cromie's (1971) finding that patterns with four elements were more difficult than those with two or three.

One curious finding in this study concerned Item #5: GREEN BLUE BLUE BLUE GREEN BLUE BLUE BLUE. This item was found to be fourth most difficult for the Pre-Operational children but second most difficult for the Concrete Operational group. One can only hypothesize about the reason for this. Perhaps the distinction between the colors GREEN AND BLUE posed a problem for the Concrete Operational group. Maybe they felt that these tasks were easy and were therefore hasty in their responses. Or perhaps this task demanded some sort of cognitive function which differed for the two groups. Again future research should be done to determine whether this finding happened by chance and if not, what the explanation might be.

In conclusion, the item analysis does, for the most part, seem to support the notion that a longer period makes for a harder pattern. Except for Item #5, it seems to indicate that the task items were of relatively equal difficulty for both groups.

Implications for Education

While this study examined a small sample of primary school children, thoughts regarding recommended practices will be given in general terms, for they are thought to be desirable for all primary children.

Piaget's research and findings are widespread in terms of literature and have been a fairly prominent feature of the teacher preparatory courses in mathematics education in Newfoundland in recent years. However, there are teachers who, for a variety of reasons have not had the opportunity to delve into the work of Piaget and his colleagues. This writer feels that, while Piaget's research is constantly being tested and challenged, and rightfully so, it has for the most part offered educators some of the most valuable information we have about young children. Thus, there should be no teacher who has not had the opportunity to review Piaget's theory of cognitive development. The teacher preparatory courses would probably be wise to include in the pre-service teachers' repetoire of experiences, situations where they could work with young children, administering some of the classic Piagetian tasks and thereby gaining a wealth of valuable insight into the child. In the case of more experienced teachers, inservice, both from the school boards, and the provincial Department of Education should be available which deal with these topics.

Incorporated into this, should be some thoughts on how to apply Piaget to the classroom. The newly graduated teacher has often got his or her head full of Piagetian theory, but once put in the classroom and given a mathematics textbook, the theory is abandoned. Teachqr education courses, especially should provide more insight into the application of this theory to the situations which present themselves in school. For example, the primary teacher should have at his or her disposal the knowledge of standard Piagetian tasks and how to interpret the responses to these so that he or she can properly identify a developmentally, delayed child as opposed to a 'lower intelligence' or even a 'lazy' child. He or she should use these tests as a measure of his or her childrens' level of cognitive maturity. The primary school teacher must be "constantly on the watch to assist the passage from one stage to the next, to encourage the dawn of understanding, to detect it when it happens and to open the way ahead" (Blackie, 1969, p. 87).

The use of Piagetian ideas in the classroom would also hopefully encourage the use of the interview technique used so much by Piaget. "Clinical interviewing techniques have begun to reflect a diminished concern with standardization in order to obtain a more complete picture of children's developing understandings of mathematical ideas and the processes that are used to produce answers." (Lesh and Landau, 1983, p. 2). "In fact, demonstrating the usefulness of clinical interview techniques and the wealth of information that is contained in incorrect responses may be one of the most significant contributions of Piaget to research in the learning of mathematics" (Carpenter, 1980, p. 153).

The interview can be used to aid the teacher in diagnosing a child's problem with a particular concept. As well, it can be an effective evaluation tool. The importance of encouraging dialogue in mathematics, is recently coming into focus as an often forgotten, yet valuable learning experience (Biggs and Sutton, 1983; Reys, Suydam and Lindquist, 1984).

With regard to curricula, the research on Piaget has a great deal to offer. The idea of developmental levels puts inherent limitations on what can be learned by children at the certain stages of development. This would seem to imply that teachers should not try to teach subtraction, for example, until the child has attained conservation of number.

Regarding this point, the writer feels that Piaget's theory has to be seen in light of other theories which have been surfacing in the research. In particular, Soviet research has largely concurred with Piaget on the existence of levels or stages of development, however it has differed on the role of instruction. "For Piaget, development is a prerequisite for learning; learning trails behind development. For Vygotsky, [Soviet researcher] the developmental process lags behind the learning process creating a 'zone of proximal development'" (Hunting, 1983, p. 58). In other words, the Soviets are of the opinion that instruction should lead development, and thus should always be aimed at a point slightly more advanced than where the child is operating. They propose "orienting instruction not toward the aspects of mental development which have already been formed, but toward those which are still forming; not 'adapting' the material being taught to existing characteristics of the child's thinking process, but introducing material which would demand of him new and higher forms of thought" (El'konin, 1975, p. 52).

It is the writers view that perhaps teachers would do well to begin instruction where the child is operating and gradually extend this instruction into newer and more challenging areas. In other words learning experiences should entice the child into more sophisticated levels of thinking, but should not frustrate a child who is not ready. What is really being said is that instruction should be individualized to the greatest degree possible.

Regarding the content of the curriculum at the primary level, it seems obvious by now that experiences in patterning should be provided at all levels. The Pre-Operational child has shown in this study that he or she can process patterns. In keeping with the conclusions regarding the role of instruction in development, it is thought that children at this level of development should have experiences in solving patterns which can be done easily and this should lead on to more challenging patterns. As well as linear patterns, geometric patterns should be a part of these experiences. The child should be encouraged to find patterns in his or her environment: in a piece of colored clothing, in a flower or plant, in rhyming words, in music, etc., as well as in numbers. The child should be encouraged to talk about the patterns he or she finds, to try and describe the rule, as well as to translate this to paper by drawing, labelling or doing numerical calculations.

As well as finding existing patterns, the child should be encouraged to design his or her own patterns. This activity would, not only deepen the child's mathematical experience, but would provide the teacher with a wealth of information regarding the child's thinking processes.

These implications will be summarized in a set of recommendations for researchers and recommendations for educators.

Recommendations

Recommendations for Researchers

1. More research is needed into the specific aspects of Operational thinking which might be prerequisite to pattern processing.
2. An extension of the interview technique with those Pre-Operational children who were unsuccessful at patterning is needed to try and determine where specifically they experience the difficulty.
3. Future research in patterning should be done in the Pre-Operational domain at a lower age level to determine whether or not the tendency to impose a pattern even in an erroneous response exists for very young children.
4. Further research using a larger selection of items should be done to try and determine whether the tendency to perseverate is related to the absence of operational thought.
5. More research needs to be conducted in patterning with operational thinking held constant and age used as a variable to determine if the tendency to alternate is age related or stage related.
6. Future studies should be conducted to decide whether or not the hierarchy of difficulty which seemed apparent in this study holds true in other situations.

7. Further research of this nature should also try and determine if the difficulty which the Concrete Operational group experienced with Item #5 was due to chance or due to some other cause.
8. It is recommended that the clinical interview/case study continue to be used in future as a valuable research methodology.

Recommendations for Educators

1. It is recommended that teacher pre-service education include situations in which the prospective teacher can work with young children, administering some classic Piagetian tasks in an interview setting.
2. Pre-service mathematics education courses as well as mathematics in-service education should provide information on Piaget's findings regarding how young children think with emphasis on it's application in the classroom.
3. Teachers should apply the Piagetian interview technique in their classroom as a diagnostic and evaluative tool.
4. Mathematical learning experiences in primary school should be individualized as much as possible.
5. Experience with patterns should be incorporated into the curriculum at all levels in the primary school, with a variety of activities to enrich the experiences.

Conclusion

In conclusion, this study has made an attempt to investigate how the young child processes patterns. It has, in some ways, used pattern processing as a means to find out more about how the child thinks. Curriculum and instruction cannot be designed by adults for young children unless some very serious consideration is given to how the child's mind operates. Only when we can begin to understand how the child thinks can we design learning experiences which will be meaningful for them and which will take them where we want them to be.

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APPENDICES

Appendix A

Piagetian Instrument

The format used for the Piagetian instrument which follows is modelled after a similar instrument designed by Brace (1974).

Piagetian Instrument

1. Conservation of Number

A) Materials: 7 red 4 cm shell macaroni.
7 blue 4 cm shell macaroni.

Procedure: Place the blue shells in a horizontal row directly in front of the subject. Place the red shells in a parrallel row directly opposite the blue shells, so the two rows are approximately 15 cm apart.

Question: Are there more blue shells, more red shells or are they the same?

(If the child answers that one is more than the other, ask him or her to fix it so that they are the same. Do not proceed until equality is established.)

Ask the child to watch carefully. Put the red macaroni into a small pile. Spread the blue macaroni into an elongated straight line.

Question: Are there more blue shells, more red shells or are they the same?

Correct Answer = the same.

B) Materials: 4 toy plastic cups.
4 toy plastic saucers.

Procedure: Place the cups in a horizontal row directly in front of the subject. Place the saucers in a parrallel row directly opposite the cups, so the two rows are approximately 15 cm apart.

Question: Are there more cups, more saucers or are they the same?

(If the child answers that one is more than the other, ask him or her to fix it so that they are the same. Do not proceed until equality is established.)

Ask the child to watch carefully. Arrange the cups into a samll pile. Spread the saucers into an elongated straight line.

Question: Are there more cups, more saucers or are they the same?

Correct Answer = the same.

C) **Materials:** 1 container of small round wooden beads (approximately 2 cm in diameter) of assorted colors.
1 clear plastic cylinder, approximately 26 1/2 cm tall, 8 cm in diameter.
1 clear plastic cylinder, approximately 26 1/2 cm tall, 4 cm in diameter.
1 large rectangular partition approximately 35 cm wide, 25 cm tall.

Procedure: Show the subject the two cylinders, turning them upside down to confirm that they are empty. Place the cylinders side by side in front of the subject. Give the subject the container of beads and instruct him or her to place beads in the cylinders in the following manner: demonstrate taking one bead in each hand and placing one bead in each container at the same time. Place the partition between the subject and the cylinders so that he or she can only see the tops of the cylinders. Instruct the subject to begin. When the thin cylinder is approximately half filled, have the subject stop. Remove the partition so the subject can see both cylinders.

Question: (Pointing to each respective cylinder) Does this one have more beads, does this one have more beads or are they the same.

Correct Answer = the same

2. Conservation of Area

A) Materials: 1 yellow plastic two-dimensional cow
1 yellow plastic two-dimensional horse
12 green 8 1/2 cm cardboard squares.

Procedure: Place the horse and the cow on the table in front of the subject, labelling each animal. Explain that the green squares are grass for the animals to eat. Arrange six squares in two rows of three beneath the horse, explaining that this is grass for the horse to eat. Do likewise for the cow.

Question: Does the horse have more grass, does the cow have more grass or do they have the same?

(If the child answers that one has more than the other, ask him or her to fix it so that they are the same. Do not proceed until equality is established.)

Ask the subject to watch carefully while you re-arrange the squares beneath the horse from 2 rows of 3, into 1 row of six.

Question: Does the horse have more grass, does the cow have more grass or do they have the same?

Correct Answer = the same

3. Class Inclusion

A) Materials: 6 green cylindrical wooden beads, approximately 1 cm long.
2 yellow cylindrical wooden beads, approximately 1 cm long.

Procedure: Show the beads and ask the subject to tell what these are. If he or she doesn't know, explain that they are beads which can be strung to make chains, etc.

Question: Are the green ones beads?

(If the child answers anything but yes, start this interview again. Do not proceed until the answer given is affirmative.)

Question: Are the yellow ones beads?

(If the child answers anything but yes, start this interview again. Do not proceed until the answer given is affirmative.)

Question: Are there more green ones or more beads?

Correct Answer = more beads

B) Materials: 2 pictures of dogs
5 pictures of cats

Procedure: Show each picture, one at a time and have the subject identify (as a cat or a dog). Continue until all seven animals have been shown and laid out on the table before the subject.

Question: Are cats animals?

(If the answer is no, question the subject to determine how he or she is classifying. If the subject's label is appropriate, for example "pets", then use this label in place of animals, and begin this interview again. Do not proceed until an appropriate label is agreed upon.)

Question: Are dogs animals?

(Do not proceed until an affirmative answer is given.)

Question: Are there more cats or more animals?

Correct Answer = more animals

C) Materials: 5 pictures of boys
3 pictures of girls

Procedure: Show each picture, one at a time and have the subject identify it (as a boy or a girl). Continue until all eight pictures have been shown and laid out on the table before the subject.

Question: Are girls children?

(If the answer is no, question the subject to determine how he or she is classifying. If the subject's label is appropriate, for example "people", then use this label in place of children, and begin this interview again. Do not proceed until an appropriate label is agreed upon.)

Question: Are boys children?

(Do not proceed until an affirmative answer is given.)

Question: Are there more boys or more children?

Correct Answer = more children

4. Classification

A) Materials: 1 set of attribute blocks consisting of the following:
1 large red triangle
1 small red triangle
1 large blue triange
1 small blue triangle
1 large yellow triangle
1 small yellow triangle
2 small red circles
1 small blue circle
1 large yellow circle
2 small yellow circles
1 large blue square
1 small blue square
1 large yellow square
1 small yellow square

Procedure: Present the set of attribute blocks in an unorganized pile. Instruct the subject to put together the things which belong together. When the child has completed his first attempt, the blocks are again mixed up randomly into a pile and the child asked to put together things which belong together, but to do it in a different way.

Correct Answer: The attribute blocks can be sorted by shape, by color, by size or by any two of these in combination. The above procedure is repeated until the child has sorted the blocks under any three of these categories without any inconsistency. If the child repeats the same system of classification over and over, or cannot find another way to classify them, assistance is given, and a correct response is duly recorded as being with assistance.

Appendix B

Piagetian Instrument
Response Record Sheet

RESPONSE RECORD SHEET

(PIAGETIAN TASKS)

SUBJECT ____________________ DATE ____________

GRADE ____________________ TIME BEGAN ____________

AGE ____________________ TIME FINISHED ____________

KEY: 1 - incorrect or no response

2 - correct response with assistance

3 - correct response unassisted

#1. Conservation of number

A) ________

B) ________

C) ________

#2. Conservation of Area

A) ________

#3. Class Inclusion

A) ________

B) ________

C) ________

#4. Classification

A) One attribute ________

B) Two attributes ________

C) Three attributes ______

Appendix C

Patterns Instrument

Patterns Instrument

Materials: approximately 100 plastic 2 1/2 cm cubes. These were an assortment of red, blue, green and yellow.
1 large rectangular partition, approximately 35 cm wide, 25 cm tall.

Procedure: Place the cubes randomly in a pile on the table to the subject's right. Explain that these blocks are for making 'trains'. Place the partition between the subject and the examiner. Explain that a train will be made behind the partition. When the partition is removed he or she must look very carefully at he how the colors in the train are arranged and choose blocks from the pile to make the train longer.

For each item given below, arrange in the pattern behind the partition from the subject's left to right. Record each response before proceeding to the next item.

Item #1.	GREEN YELLOW GREEN YELLOW
Item #2.	RED BLUE YELLOW RED BLUE YELLOW
Item #3.	GREEN BLUE RED YELLOW GREEN BLUE RED YELLOW
Item #4.	BLUE YELLOW YELLOW BLUE YELLOW YELLOW
Item #5.	GREEN BLUE BLUE BLUE GREEN BLUE BLUE BLUE
Item #6.	GREEN RED GREEN GREEN GREEN RED GREEN GREEN

Appendix D

Patterns Instrument
Response Record Sheet

This response record sheet for the patterns instrument which follows is modelled after a similar record sheet used by Cromie (1971).

Response Record Sheet for Patterns Instrument

SUBJECT ____________________ DATE ____________

GRADE ____________________ TIME BEGAN ____________

AGE ____________________ TIME FINISHED ____________

	MODEL								RESPONSE
#1.	G	Y	G	Y					
#2.	R	B	Y	R	B	Y			
#3.	G	B	R	Y	G	B	R	Y	
#4.	B	Y	Y	B	Y	Y			
#5.	G	B	B	B	G	B	B	B	
#6.	G	R	G	G	G	R	G	G	

NOTES

Appendix E

Key to Patterns Instrument

Response Record Sheet for Patterns Instrument

SUBJECT ______________________ DATE __________

GRADE ______________________ TIME BEGAN __________

AGE ______________________ TIME FINISHED __________

	MODEL	RESPONSE
#1.	G Y G Y	G Y G Y
#2.	R B Y R B Y	R B Y R B Y
#3.	G B R Y G B R Y	G B R Y G B R Y
#4.	B Y Y B Y Y	B Y Y B Y Y
#5.	G B B B G B B B	G B B B G B B B
#6.	G R G G G R G G	G R G G G R G G

NOTES