INVESTIGATING ELEMENTARY CHILDREN'S UNDERSTANDING OF EARTH'S SHAPE, GRAVITY, AND POSITION IN SPACE

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CHAPTER I

INTRODUCTION

Joe Miller on Dimensions:

> If the earth were only a few feet in diameter, floating a few feet above a field somewhere, people would come from everywhere to marvel at it. People would marvel at its big pools of water, its little pools and the water flowing between the pools. They would marvel at the bumps and the holes and the very thin layer of gas surrounding it. The ball would be the greatest wonder known, and people would come to pray to it, to be healed, to gain knowledge, to know beauty and to wonder how it could be. People would love it and defend it with their lives because they would somehow know that their lives could be nothing without it. If the earth were only a few feet in diameter.
>
> -- Not Man Apart (Friends of the Earth)

What an experience it would be to step out into space and view the earth in this way, to visualize for the first time our planet as a whole. How sobering it must be to realize the earth's unique position in the solar system. How much more we might appreciate and value our relationship to the envelope of life and the planet it surrounds if we could take this viewpoint? Unfortunately, at present the experience is reserved for the select few who have traveled in space. Being earth bound, how does one develop a holistic view and appreciation of our planet?

Investigating elementary children's understanding or "notion" of earth is the focus of the research presented here. From an educational standpoint, development of the earth notion has significance for instruction and curriculum development for the social sciences as well as the physical and biological sciences. The concepts of earth's shape, gravity and position in space are included in the study of subjects such as geography, history, astronomy, physics and ecology, to mention a few. Perhaps most importantly though is the significance of the earth notion to the field of environmental education. Our earth is a finite body in space. Children must grasp this idea before we can expect them to deal with the interdisciplinary aspects of environmental education such as conservation of resources and pollution control. The relationship between concept formation and the awakening of a sound environmental and conservation ethic may be predicated by the development of a notion of earth as a finite body in space.

The intent of this researcher is to contribute to a growing body of knowledge that will aid human beings to better comprehend the development of the earth notion. Armed with this knowledge we may better apply our collective efforts to maintain and appreciate this earth that sustains us.

Statement of Purpose

The purpose of the research reported here is to replicate the interview procedures and to secure information from two of the four psychological tasks used by Sneider and Pulos (20) in their investigation of children's notions of earth. [20] In addition to replicating Sneider and Pulos' work, this study differs in that it includes: (1) a rural population, (2) an additional grade level (kindergarten), and (3) a home and school survey to identify possible sources of information related to earth. Data from a rural population and the inclusion of kindergarten students, a grade level for which no previous data existed, adds a broader perspective to existing data on children's notions of earth. Cultural sources of information have also been suggested as contributing significantly to earth notion, and the surveys used in this study explored those sources in more depth than did previous studies.

The following questions guided the research:

1. What are the earth notions held by kindergarten, second, fourth, and sixth grade students from a rural Oklahoma community?
2. Is there a relationship between notion level and school grade level?
3. Is there a relationship between the distribution frequency for each notion level by age in the Oklahoma population and the non-Oklahoma population?
4. What are the sources of information in the home that contribute to the child's notion of earth?
5. Is the amount of school instructional time devoted to earth concepts related to notion level?
6. Is there a relationship between verbal ability and notion level?
7. Is there a relationship between the ability to shift spatial reference frames and notion level?
8. Is there a relationship between children's earth notion level and a combination of sex, age, grade, achievement scores, and parents' years of education?

Definitions of Terms

1. Earth Notion - Three basic concepts are included in the earth notion: 1) the earth is spherical in shape; 2) the earth is surrounded by space; and 3) things fall toward the center of the earth.
2. Misconceptions - Concepts held that are at variance with formal instructional model.
3. Preconceptions - Concepts held prior to formal instruction.
4. Alternative Frameworks - Autonomous frameworks for conceptualizing experiences with the physical world, alternative interpretations.
5. Cultural Sources of Information - Experiences encountered through home, school and community life.
6. Preconceptual Thinking - Conceptions at variance with the accepted scientific conceptions.

Null Hypotheses

The following null hypotheses represent questions 2-8.

HO_1. There is no significant relationship between grade level and notion level in the sample population.

HO_2. There is no significant relationship between the frequency distribution for each notion level by age in the Oklahoma population and the non-Oklahoma population.

HO_3. There is no significant difference in the parents' perception of their child's experiences. Sources of information in the home do not contribute significantly to childrens' earth notion level.

HO_4. The amount of school instructional time on earth concepts is not significantly related to notion level.

HO_5. The relationship between verbal ability and earth notion level is not significant.

HO_6. There is no significant relationship between the ability to shift spatial reference systems and notion level.

HO_7. There is no significant relationship between earth notion level and age, grade, achievement scores, parents' years of education and sex.

CHAPTER II

REVIEW OF LITERATURE

Introduction

An extensive library and ERIC search revealed related literature categorized in three general groups: 1) developmental readiness, 2) alternative conceptual frameworks, and 3) earth notion research.

Developmental Readiness

Readiness for subject matter has long been an issue in education and psychology. Though related in many ways, the psychologist and the educator have somewhat different emphases in their research pursuits. The psychologist's primary purpose is in development and analysis of general laws of cognitive development, while the educator looks for the implications of such theory for classroom application. [12, p. 2-3] The following review of psychological theory suggests the educational significance of the development of earth notion in elementary children.

The theories of Piaget, Bruner and Gagne have several points in common, but each places different emphasis on the importance of experience versus maturation in determining readiness. [6, p. 259] [12, p. 119]

Piaget, well known for his stages of cognitive development and interview methods for probing children's thoughts, places a strong emphasis on maturation. Jerome Bruner's stages of development are similar to Piaget's but more attention is given to the role of cultural and social experiences in cognitive growth. Both Piaget and Bruner stress the importance of interaction between experiences and biological maturation as the child develops his own cognitive system. [6, p. 259]

Much of American psychological research has been directed at acceleration of the stages of development. Piaget is in general negative on this subject. While he does not deny that acceleration is possible, he questions its advisability. Optimal time for intervention is not necessarily minimal, and optimal time for any given child is still a question. [16, p. 132]

Newell (12) in his guide to Gagne's <u>Conditions of Learning</u> points to a shift in the idea of readiness from a passive view to an active one. Gagne's position is that we can control external factors to promote readiness. He believes a child can learn any concept if he/she has the prerequisite learning or experiences. [12, pp. 119-120] Gagne's learning heirarchy presents a very structured, controlled avenue for the attainment of skills. This plan is quite similar to the cognitive mapping approach of Ausubel. [18]

Ausubel, like Gagne, points out that all learning for the child begins with concepts he already possesses, his existing conceptual framework. Connections must be made between this knowledge and new concepts to be learned. Unlike Gagne, Ausubel stresses the need for sequential organization of subject matter moving not from easy to more difficult but from general to specific. [11]

Wohwill (23) emphasizes that in the teaching of scientific and mathematical subjects to young children the focus should be on the "enrichment of their experiences, aimed at generalization and transfer, rather than on acceleration per se." [23, p. 100] This viewpoint is consistent with the view of Piaget and Bruner. The preoperational child in particular must experience his world by poking, prodding, smelling and tasting. Lacking the ability for concrete and formal operations, this is the means by which he learns, and is the foundation on which later learning takes place.

Regardless of whether one accepts the approach of Bruner and Piaget or that of Gagne and Ausubel, the sequential nature of cognitive growth and the importance of experience remain common themes in both. Therefore, major objectives of this study were to explore the developmental nature of the earth notion in a cross-age sample and the significant cultural experiences related to acquisition of earth concepts.

Alternative Conceptual Frameworks

One of the fundamental concepts for children of all grade levels to understand, in dealing with many curriculum areas, is the notion of earth. The earth notion has been defined in previous studies as a spherical planet surrounded by space with objects falling toward the center of the sphere. [15] These characteristics of our planet are essential for the child to comprehend before he/she is able to fully grasp such ideas as reflected by these questions: What causes day and night? Why do we have different seasons? How can people live on a ball and not fall off? Why does it get light in New York before it does in California? If a ball is thrown up into the air, will it always come back down? How is it that the top of a sail is the last thing we see as a boat sails out of sight? Why must we conserve energy, water and other natural resources?

Accommodation of this basic but complex notion of earth means the child must make a transition from an egocentric point of view to a non-egocentric point of view. He/she must take a viewpoint outside his own personal reference frame. Educational research has repeatedly pointed out this transition in children's thinking. Karplus, in his report on the Science Curriculum Improvement Study, remarked:

> It seems to me that in general this transition in children's thinking is not recognized by present educational practice in the United States. Teachers with whom I have been in contact have not seemed to be much aware that there is such a change taking place. I would say most instruction above kindergarten takes place on what we might call the formal level. [7, p. 113]

Twenty years have passed since this observation was made yet, the same could be said of much of the instruction observed by this researcher. Even at the secondary level research has shown that much of the instruction and subject matter in science courses is on a formal level while a majority of students remain at a concrete operational level. [9]

The purpose of this study was to investigate the transitions in elementary children's understanding of the notion of earth. If educators are to provide appropriate experiences for the development of a mature conceptual framework of the earth, they must first determine where the child is in his present understanding. What notion does he/she already have about our planet, earth? When and how do these notions develop?

The variety of children's alternative frameworks of earth and their progression from an egocentric to a non-egocentric point of view is a result of both cognitive development and access to cultural sources of information (e.g. school, television, and books). [20] As a result of this development, children come to the instructional situation with an existing set of preconceptions. (Preconception, as used in this paper, is a term used to mean preexisting framework. Preconceptions, misconceptions and alternative frameworks are used interchangeably in the literature.) It is when these preconceptions differ greatly from scientific conceptions that educators must be aware. Ausubel, Novak and Hamesian (2) point out that "preconceptions are amazingly tenacious and resistant to extinction" and the "unlearning of preconceptions might prove to be the most detrimentive single factor in the acquisition and retention of subject matter knowledge." [2, p. 372] It has been shown that when misconceptions are not uprooted, they may become even more elaborated and stable as a result of instruction. [12]

Central to the issue of developing a sequential organization for instruction is making teachers aware of their students' alternative frameworks or preconceptions. [12] The term alternative framework is preferred since in fact many of the alternative explanations offered by children are examples of thinking that is quite perceptive. As Ault (1) put it, they are "intelligently wrong." Teachers have a tendency to listen only for right answers. Yet,

> ...when thinking freely and expressing themselves without fear of being wrong, children often surprise us with thoughts that are novel but not nonsensical or illogical... they are doing some creative albeit unpolished thinking. [1, p. 24]

Nussbaum and Sharoni-Dagan (14) argue that children's alternative frameworks should always be considered in the development of curriculum, instruction and evaluation. Driver and Easley (6), in their review of literature on concept development in the physical sciences, however, point out that "development of a taxonomy of misconceptions does not give us interpretive power. Not until the reasons for the misconceptions are understood will progress be made in instructional terms." [5] This research related some factors in the cultural background and experiences of children in an effort to uncover some of the reasons for the alternative frameworks about earth notion. A need also exists for the development of curriculum materials contrasting children's conceptions with scientific conceptions. [19] Continuing expansion of our understanding of children's thoughts on concepts such as earth notion will aid in this curriculum development.

Earth Notion Research

Nussbaum pioneered the research on children's notions of earth in his Ph.D. dissertation at Cornell University in 1972. In 1976 Nussbaum and Novak reported structured interviews assessing second grade children's understanding of earth's shape, gravity and position in space and assessing the impact of a series of audio-tutoral lessons designed to give instruction on the concept. Little progress was made as a result of the audio-tutorial instruction in this early study; however, five qualitatively different notions were identified. [15]

Nussbaum continued his research in 1979, studying the notions of earth held by fourth to eighth grade children in Jerusalem, Israel. He replicated his previous research, using a slightly different interview instrument, and found that older children also hold five distinct notions about earth's shape and gravity with varying frequencies at each age. [13] A few modifications in the original notion level scheme resulted from the findings of the second study. Combining the original notion levels I and II and adding a new notion level II, Nussbaum created the resulting scheme and descriptions of levels as presented in Figure 1.

> Notion I refers to the belief that the earth is just as it appears to inhabitants on the surface--flat. Although children in this category are likely to say "round" when asked what they believe the shape of the earth is, further probing shows that they have attached a meaning to the words "round earth" that does not conflict with their immediate perceptions. For example, some children believe that the round earth refers to curved roads or to mountains; others believe the earth is a circular island around which people can sail or fly; still others classified at Notion I believe that "Earth" is a planet up in the sky, where only astronauts go. Questions about gravity would make very little sense to children who hold Notion I.
>
> Notion II is a particular model of the world which retains the flat earth concept, but which also incorporates the ideas of cosmic space. When asked to explain their ideas about the round earth, these children claim that the earth is indeed a round ball in space, but people live "on the flat part in the middle." The upper half of the ball is the air, and the lower half of the ball is made of soil and rocks.
>
> Children who hold Notion III understand that the earth they see is a tiny part of a great ball in space. They believe, however, that there is an absolute "up" and "down" in space, so that people can only live on "top" of a ball-shaped earth.

Children who believe in Notion IV realize that we live on the surface of a great ball, represented by the globe, and that people live all around the ball without danger of falling off. Children whose responses are classified as Notion IV will correctly show how rocks fall when dropped just above the earth's surface, but will revert to the "absolute down" idea when asked to predict how objects fall when dropped into tunnels inside of the earth. For example, these children predict that a rock dropped from the North Pole into a hole dug straight through the earth will fall all the way to the South Pole and either land on the earth's surface somewhere near the edge of the hole, or "float freely" at its southern entrance.

Children who hold Notion V understand that objects always fall toward the earth's center. In contrast to a Notion IV response that a rock will fall all the way to the South Pole, children at this level say that the rock will stop at the earth's center. [20, p. 206]

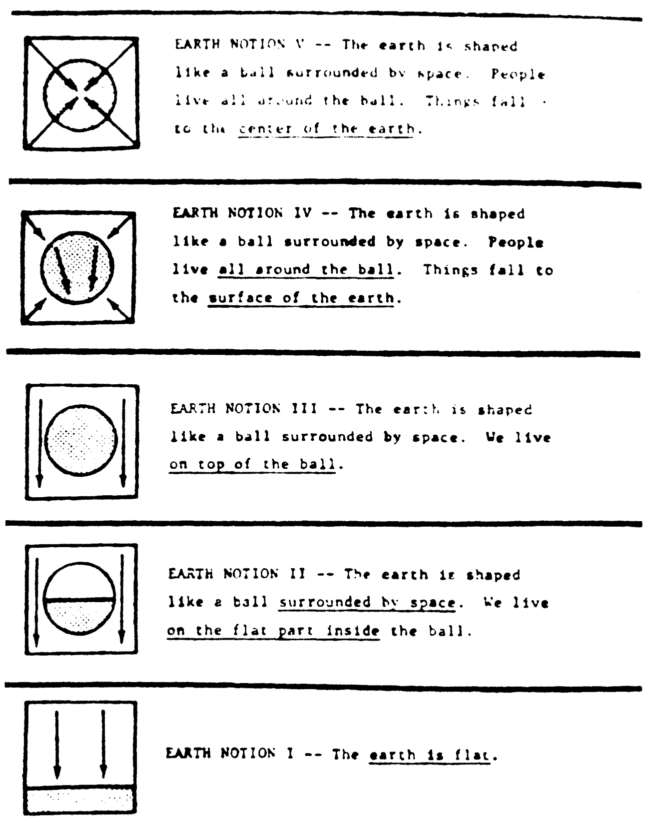


Figure 1. Earth Notion Classification Scheme

As pointed out in Nussbaum's research, changes in the child's earth notion are considered as "acts of cognitive accommodation." As the child is presented with new information at variance with his existing conceptual framework, he must change his notion to accommodate this information. The new notion, however, may still not represent a scientific conception.

Mali and Howe found very similar notion levels in the children of Nepal and of America. A study of 250 Nepalese children, ages 8, 10 and 12, (10) compared the earth notion held by children of another culture with those of American children. This study included the relationship of earth notions to three Piagetian tasks, sex, parents' occupation, games, travel, number of languages spoken, grade, years of schooling, information sources and chores. They also found support for the hypothesis that notion level increases with age. Other variables found to be significantly correlated with notion level were (1) level of cognitive development assessed by the Piagetian tasks of conservation, seriation and classification, (2) number of years of schooling, and (3) sources of information available in the home (newspaper, radio, etc.).

Klein (8) studied earth and sun system concepts of second grade Mexican-American and Anglo-American boys and girls in St. Paul, Minnesota. The research was designed to determine if there were any differences in the responses of the two groups or between the sexes. No differences were found between sexes; however, Mexican-American children exhibited more preconceptual thinking than Anglo-American children. Many of the responses described by Klein were very similar to Nussbaum's findings; however, the models were sufficiently different to prevent direct comparison. [8]

Nussbaum and Sharoni-Dagan's research (14) tested the impact of a revised earth concept audio-tutorial instructional unit. The study involved second graders in Jerusalem. A quasi-experimental design was employed where second grade students' responses were compared with responses from fourth grade students who had no conventional instruction about the earth, and responses from sixth grade students who had received conventional instruction on the earth. Findings showed the impact of as little as 80 minutes of audio-tutorial instruction on the earth, which equated to an increase in more than two years of incidental concept development. Nussbaum and Sharoni-Dagan found in the study that primary age children are capable of learning major science concepts given "appropriate, carefully sequenced instruction rich in concrete visual aids and props." [14]

The most recent work of the earth notion studies was conducted in California, with third to eighth graders from the San Francisco Bay Area. Sneider and Pulos (20) found once again a variety of earth notion levels and an increase in notion levels with age. Through their research Sneider and Pulos proposed an alternative model to the Nussbaum model for describing expected notion levels. The new model "offered a significant improvement in accuracy (with a very small loss in precision). This model provides for an additional notion between Notions III and IV. Subjects in this category (14% of the sample) understood that objects fall towards the surface of the earth, but failed to grasp that people live 'under our feet,' on the other side of the world." In addition several other variables related to notion levels were analyzed including four psychological tasks and gender. Verbal ability, spatial reference frame and gender were found to be significant predictors. Children with high verbal ability, boys, and children who were able to shift spatial reference frames performed better on the earth notion interview. [20]

Summary of Review of Literature

As pointed out in the literature, an understanding of the earth notion is dependent on both experiences and cognitive development, making these significant variables in this study. As identified in the literature, it is of great importance to expose the alternative frameworks of children to other views. It is suggested that this may prevent further reinforcement and elaboration which may make future accommodation of a more formal conceptual view difficult. The relatively limited number of studies conducted on the subject of children's understanding of earth suggests the need for more research. There is a need to 1) better understand the nature of children's earth notion, 2) verify the earth notion classification scheme, suggested by Nussbaum, with different populations, and 3) explore more fully other variables and experiential factors affecting earth notion.

CHAPTER III

METHODS AND PROCEDURES

Subjects

Subjects for the study were selected from the Meeker Public Schools, Meeker, Oklahoma. The Meeker population was chosen because of anticipated cooperation from the school system and the familiarity of the researcher with the community and the school administration. In addition, this population represents a small midwestern community in contrast to the urban and suburban populations of Ithaca, New York; St. Paul, Minnesota; San Francisco Bay Area, California; or Jerusalem, Israel, of previous studies. (Mali and Howe included a rural population and an urban group in their study of children in Nepal.) [10]

The Meeker Public School District is located in southern Lincoln County in central Oklahoma. The district's largest population cluster is the City of Meeker (1979 population 683). The district's population is predominantly rural, non-farm, basically caucasian with a small percentage of blacks and a sizeable population of native Americans. Meeker is approximately 35 miles east of Oklahoma City, the state's capital and largest city. Government is the largest single employer in the area, followed closely by manufacturing. [21]

The school itself is divided into the elementary school with grades K-5, the middle school with grades 6-8, and the high school with grades 9-12 (K-6 population = 360 students). The elementary school has two sections per grade with class sizes of 20-25 students per section. For this study 12 male and 12 female students were randomly selected from each of the kindergarten, second, fourth, and sixth grade sections. Five subjects were excluded due to lack of parental consent. The following 91 subjects were included in the study: Kindergarten--11 boys, 11 girls; second--11 boys, 13 girls; fourth--12 boys, 10 girls; sixth--10 boys, 13 girls; total--44 boys, 47 girls.

Instruments

An important aim of this research was to replicate as closely as possible the instrumentation of previous studies. However, given the time and budget constraints, only two tasks in addition to the earth notion interview were included. The verbal opposites task and the water level task were selected for inclusion due to their demonstrated significance in the California study. The Nepal study showed a relationship between notion level and cognitive level. Mali and Howe used three Piagetian tasks as indicators of cognitive level; however, the water level task (another in the same line of Piagetian tasks) is used here as a measure of cognitive development.

Other instruments used in this study were the earth notion interview format of Sneider and Pulos and the cultural sources of information surveys developed by the author. The earth notion interview format (although varying slightly from study to study) has been found to be a valid predictor in each of the previous studies for identifying the child's understanding of earth. The cultural sources of information surveys were field tested with parents and teachers in Ponca City, Oklahoma, to give the author information about questions that might need clarification in wording. The content is in part a reflection of the sources of information included for study by Mali and Howe in the Nepal study.

A list of the instruments and a brief description of the structured interview follows.

1. Earth Notion Interview Format [20] -- The interview consists of a series of open-ended questions exploring the child's concepts prior to being exposed to props or visuals. Props included a globe, detachable stick figures, two styrofoam balls with tunnels through them, and drawings to represent different spatial situations. See Appendix A for a complete review of the interview questions.
2. Water Level Task [22] -- This Piagetian task measures the child's ability to shift spatial reference frames. Three drawings of identical empty bottles are presented to the child one at a time. The child is asked to draw water in each bottle so that it is half full. The bottles are positioned vertically, horizontally and diagonally. This task is an indicator of cognitive level. See Appendix B for drawings.
3. Verbal Opposites Task [4] -- The task is a measure of verbal I.Q. As a word is read, the child is asked to respond with a word meaning the opposite. See Appendix C for the list of words.

4. Cultural Sources of Information Survey -- This instrument, developed by the author, includes two parts, the survey for the parents and the survey for the teachers. The parent survey asks for information about such matters as travel, television, books and conversations with parents about earth concepts. The teacher survey was administered to determine the amount of time spent on instruction of earth concepts, as well as other school related experiences. Appendix D includes copies of both surveys.

Design

The study utilized a basic correlational design in which the dependent variable, individual children's notion level, was correlated with each of the independent variables: age, sex, achievement scores, parents' years of education, cognitive level (spatial ability), instructional time on earth concepts, verbal ability and cultural sources of information in the home. The earth notion frequency profile for the Oklahoma data was also correlated with the frequency profile for non-Oklahoma data.

Procedures

During March of 1984 class lists were obtained from the kindergarten, second, fourth and sixth grades. From these lists 24 students from each grade were randomly selected (12 boys and 12 girls). Permission forms were sent home with these students to secure family cooperation. A few families chose not to participate and after reselection, 91 students made up the sample population.

A pilot study was conducted during April, 1984, in Ponca City, Oklahoma, with 14 students in grades K, 2, 4, and 6. The pilot provided information for refinement of the interviewer's technique and wording of the surveys.

Before beginning the interview procedure, the researcher spent 30 to 45 minutes with each class (K, 2, 4, 6) conducting outdoor education activities. This get-acquainted activity was to insure a more relaxed relationship between the researcher and the subjects during the interviews.

Thirty to 45 minute interviews were conducted by the researcher with individual students beginning the last week of April and continuing to the middle of May. The earth notion interview was followed by the water level task and finally the verbal opposites task. Responses were tape recorded and annotated in the interview booklet.

A few variations in the interviews were necessary. Kindergarteners who indicated they had never heard of the earth in the initial drawings were then shown a model of the earth and asked if they had ever seen one before and what it was. If the child responded by saying it was the earth, the interview continued as before. For those who still had no idea of what the earth was, questioning was discontinued. Older students who showed discrepancies in their responses about gravity were asked additional questions at the end of the interview to clarify the child's intended meaning (i.e. What direction is down from various points on the earth's surface? Where is gravity strongest? On the surface? In the middle? Outside the ball? etc.)

Interview data were analyzed and classified by the researcher. Using the Nussbaum classification scheme students were assigned to a notion level. During the classification process several transitional levels were identified as well as one deviation from the five level scheme. Two students expressed a belief that gravity is in the atmosphere pushing things to the surface. In all other responses these two exhibited an understanding at level 4. Therefore, in all statistical analyses they were placed at level 4. Students who were seen as being in transition were classified into the next lower level for purposes of statistical analysis.

After the completion of the interview procedure, parent surveys were sent home with each participant including a self-addressed stamped envelope for easy return to the researcher. Teachers were also given surveys. An initial 50 percent of the parent surveys were returned and 100 percent of the teacher surveys. A second mailing of the parent survey yielded an additional 10 percent response.

Data Analysis

Earth notion interview data were analyzed by the researcher and students were assigned to a notion level using the criteria of Nussbaum (13) Cognitive level, as demonstrated by the water level task, was determined as level one when the child related only to the spatial reference frame with the bottle held vertically, level two with the bottle held vertically and horizontally, and level three with the bottle held vertically, horizontally and diagonally. Verbal opposite raw scores were analyzed using standardized norms (although raw scores were used in statistical analysis).

The test for trend in contingency tables was applied to determine the relationship between notion level and grade level. The correlation of notion level distribution by age between Oklahoma and non-Oklahoma data utilized the Chi-square Test of Independence in contingency tables.

Statistical analysis of the relationship between the dependent variable, notion level, and the independent variables of television, travel, planetarium/omniplex visits, games, literature, use of telescopes and globes, and family discussions was accomplished using multiple correlation and stepwise regression. Multiple correlation was also used to compare notion level with sex, age, grade, achievement scores, mother's and father's years of education.

Spearman Rank Order Coefficient of Correlation (corrected for ties) was used to determine the individual correlation between notion level and cognitive level, notion level and verbal ability, and notion level and instructional time.

Mean scores for achievement, verbal ability and parents' education for each grade were calculated. Statistical significance in all tests was predetermined and set at the 0.05 level of probability.

Raw data were compiled by the author and analyzed by computer. To compensate for a small N, regrouping of the notion levels was necessary in two of the statistical tests. Earth notion levels 1-3 were grouped to represent notions in which students exhibit an egocentric view of gravity. Levels 4-5 represent notions in which students have a much less egocentric view of gravity. For the comparison of Oklahoma data and non-Oklahoma data the 7-9 year olds and the 10-12 year olds were grouped, again due to a small N in the Oklahoma sample.

CHAPTER III

RESULTS AND DISCUSSION

Statistical Data

H_o1 There is no significant relationship between grade level and notion level in the sample population.

Results

A profile of earth notion frequency by grade is presented in Table I. Transitional levels are also indicated. Often a child gave responses revealing a partial understanding of higher level concepts. Therefore, these levels represent a finer discrimination in the understanding of some students. These students may actually be in a state of disequilibrium, an optimal stage for instructional intervention.

Results of the test for trend analysis clearly shows a tendency for notion level to increase with grade. The relationship between notion level and grade is statistically significant ($p = 0.00$) therefore allowing rejection of the null hypothesis. The highest percentages of both kindergarten and second graders were in levels 1-3, while the highest percentages of fourth and sixth graders were in levels 4-5. Results are given in Table II. Notice the fourth grade group has a higher percentage in levels 4-5 than does the sixth grade. Three factors may offer some clues to the anomaly seen here. First,

TABLE I

NOTION LEVEL FREQUENCY PROFILE BY GRADE IN THE OKLAHOMA SAMPLE

	NOTION LEVELS									
Grade	0	1	1-2	2	1-3	3	3-4	4	4-5	5
K n = 22	3	10	0	1	1	1	1	4	0	0
2 n = 24	0	8	3	2	0	2	0	7	1	0
4 n = 22	0	0	0	0	0	2	4	6	7	2
6 n = 23	0	0	0	6	0	2	1	6	5	3

TABLE II

CHI-SQUARE ANALYSIS OF THE RELATIONSHIP OF EARTH NOTION LEVEL TO GRADE LEVEL

		GRADE				
		K	Second	Fourth	Sixth	Total
	Frequency	18	15	6	9	48
1-3	Expected Frequency	11.6	12.7	11.6	12.1	
	Percent	19.78	16.48	6.59	9.89	52.77
	Frequency	4	9	16	14	43
4-5	Expected Frequency	10.4	11.3	10.4	10.9	
	Percent	4.4	9.89	17.58	15.38	47.25

Chi-Square = 15.815 df = 3 p = 0.00

the fourth grade had slightly higher mean parent educational levels than the sixth grade and second the fourth grade had higher mean achievement scores. Third, the sixth grade teacher also reported having spent less instructional time on earth concepts than did fourth grade teachers. Mean scores for parents' years of education and achievement scores are presented in Table III. (Kindergarten scores are from the Metropolitan Readiness Test; and second, fourth and sixth grade scores are from the Metropolitan Achievement Test).

H_o2 There is no significant relationship between the frequency distribution by age for each notion level in the Oklahoma and non-Oklahoma populations.

Results

The frequency distribution by age for each notion level in the Oklahoma sample is found in Table IV.

Kindergarten data were not included in the statistical analysis since no previous data existed for comparison. Using the Chi-Square Test of Independence in contingency tables, there was a statistically significant ($p = 0.00$) relationship between the Oklahoma and non-Oklahoma data. The Oklahoma sample had a higher frequency of students in earth notion levels 4-5 than did non-Oklahoma samples. In the 7-9 year old group there were 50 percent from the Oklahoma population in the notion group 4-5 as opposed to only 10.09 percent in the 4-5 level in the non-Oklahoma population. The 10-12 year old Oklahoma group also had 36.05 percent more in level 4-5 than did the non-Oklahoma population. Results are presented in Tables V-a and V-b.

TABLE III

MEAN VALUES BY GRADE FOR FOUR INDEPENDENT VARIABLES

GRADE	VARIABLE	N	MEAN	RANGE
	Achievement	22	59.18	28 - 72
	Verbal I.Q.	22	19.68	6 - 33
K	Years of Education			
	Mother's	14	13.21	12 - 17
	Father's	14	14.71	12 - 17
	Achievement	24	162.88	96 - 209
	Verbal I.Q.	24	35.46	19 - 47
2	Years of Education			
	Mother's	16	12.75	9 - 16
	Father's	16	12.25	8 - 18
	Achievement	21	195.29	115 - 251
	Verbal I.Q.	22	47.55	32 - 64
4	Years of Education			
	Mother's	10	13.2	12 - 17
	Father's	10	13.7	12 - 18
	Achievement	22	190.59	72 - 253
	Verbal I.Q.	23	50.22	34 - 63
6	Years of Education			
	Mother's	15	12.2	10 - 13
	Father's	14	13.21	11 - 16

One explanation for these findings may be found in the research suggesting that children in rural areas have better spatial perceptual ability than children in urban or suburban areas (such as Jerusalem, San Francisco, etc.). [3]

TABLE IV

EARTH NOTION LEVEL FREQUENCY PROFILE BY AGE IN THE OKLAHOMA SAMPLE

	NOTION LEVELS				
Age/Years	1	2	3	4	5
5	4	1			
6	11		2	3	
7	3		1	3	
8	8	2	1	7	
9			2	8	
10			3	5	2
11		3	1	6	1
12		3	3	6	2
Total	26	9	13	38	5

$H_0 3$ Sources of information in the home do not contribute significantly to children's earth notions.

Results

Sources of information identified in the parent survey were found to contribute significantly to notion level. The Multiple Correlation

TABLE V

FREQUENCY DISTRIBUTION OF OKLAHOMA AND NON-OKLAHOMA NOTION LEVEL DATA BY AGE

Table V-a

Age Group = 7-9 Year Olds

		NOTION GROUP 1-3	4-5	Total
Oklahoma Data	Frequency	17	17	34
	Expected Frequency	28.7	5.3	
	Row Percent	50.0	50.0	100.0
Non-Oklahoma Data	Frequency	196	22	218
	Expected Frequency	184.3	33.7	
	Row Percent	89.92	10.09	100.0
	Chi-Square = 35.811	df = 1		p = 0.00

Table V-b

Age Group = 10-12 Year Olds

		NOTION GROUP 1-3	4-5	Total
Oklahoma Data	Frequency	13	22	35
	Expected Frequency	24.5	10.5	
	Row Percent	37.14	62.86	100.0
Non-Oklahoma Data	Frequency	273	100	373
	Expected Frequency	261.5	111.5	
	Row Percent	73.19	26.81	100.0
	Chi-Square = 19.836	df = 1		p = 0.00

Coefficient (. R = 0.76) was statistically significant at the 0.01 level of probability, thus allowing rejection of the null hypothesis.

Close analysis of the experiences contributing in the multiple correlation equation reveals that time spent on tall mountains, time spent using telescopes, and time spent reading books about the earth were the three experiences contributing most significantly to notion level. A prioritized list of experiences is found in Figure 2.

Time spent in the following experiences:

1. Trips to the Mountains
2. Using Telescopes
3 Reading Books
4. Parental Discussions of Travel
5. Parental Discussions of Earth's Gravity
6. Parental Discussions of Earth's Position
7. TV/NASA
8. TV/Karl Sagan
9. Parental Discussions of Earth's Shape
10. Trips to Planetariums
11. Parental Discussions of Day and Night
12. Use of Globes
13. TV/321 Contact
14. Games
15. TV/Nova
16. Airplane Trips
17. Trips to the Omniplex
18. TV/Other Educational Programs
19. Parental Discussion of TV Programs

Figure 2. Home Experiences Contributing to Notion Level in Order of Significance

H_o4 The amount of school instructional time on earth concepts is not significantly related to notion level.

Results

Teachers were asked to indicate the amount of instructional time they spent on earth concepts (Table VI). The kindergarten teacher reported that she did not spend time teaching earth concepts (however, a number of students referred to their teacher as a major source of information). The two second grade teachers indicated that they spent about 90 minutes in earth notion instruction and the two fourth grade teachers spent more than 90 minutes teaching earth concepts. The sixth grade teacher spent about 30 minutes of class time on earth concepts. The Spearman Correlation Coefficient for the relationship between notion level and amount of instructional time was 0.38 with $p = 0.00$ making it statistically significant. Therefore, the null hypothesis was rejected.

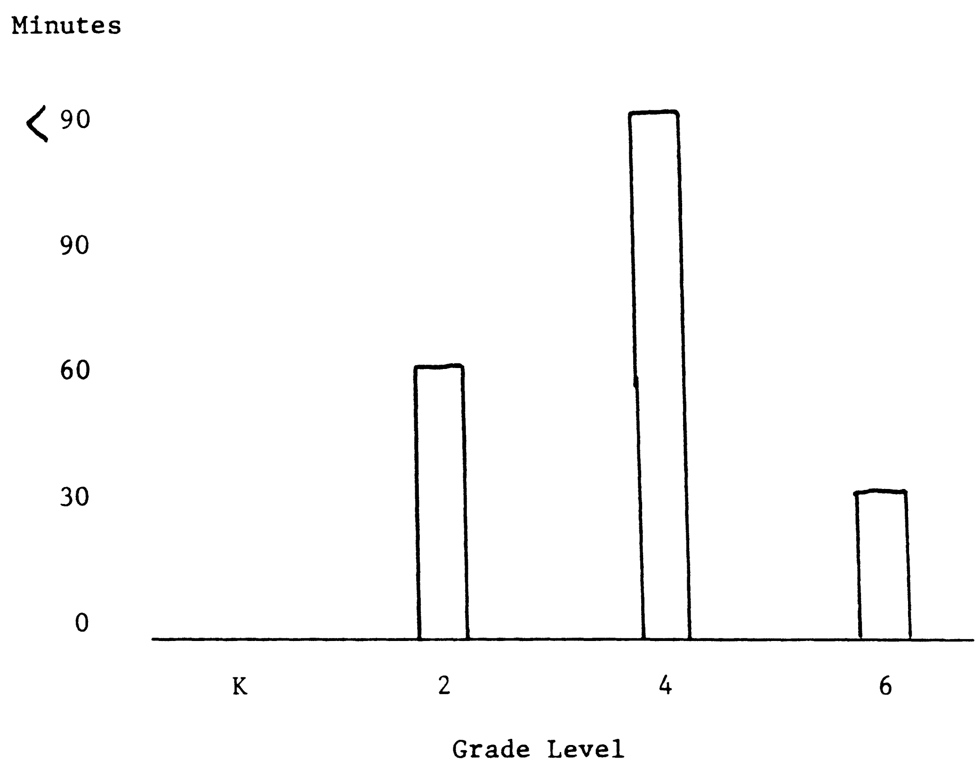
H_o5 The relationship between earth notion and verbal ability is not significant.

Results

Verbal ability, as measured by the verbal opposites task, for each grade in the sample is shown as mean raw scores in Table III. The Spearman Correlation Coefficient for the relationship between verbal ability and notion level was calculated as 0.70 ($p = 0.00$) therefore allowing rejection of the null hypothesis. Verbal ability is highly correlated with notion level. This relationship was also found in the California study.

TABLE VI

AMOUNT OF INSTRUCTIONAL TIME
ON EARTH CONCEPTS



H_o6 There is no significant relationship between the ability to shift spatial reference systems and notion level.

<u>Results</u>

As stated earlier, the ability to shift spatial reference systems on the water level task is used here as a measure of cognitive level. Cognitive level was found to be statistically significant in its relationship to notion level having a Spearman Correlation Coefficient of 0.46 ($p = 0.00$).

$H_o 7$ There is no significant relationship between earth notion level and age, grade, sex, achievement scores and parents' years of education.

Results

The multiple correlation coefficient for the relationship between the dependent and independent variables was calculated as $R = 0.70$ ($p = 0.00$). A closer look reveals two variables as contributing most significantly to this multiple correlation. Student achievement scores and sex were significant at probability levels of 0.00 and 0.01, respectively. The variable of sex was negatively correlated. A look at raw data on sex and notion level in Table VII shows that more males ranked in the fourth and fifth notion levels than did females.

Anecdotal Data

The five notions identified in previous studies were again found in the sample population of this study. The only deviation from this classification scheme was that of the two students (a second and a fourth grader) who indicated that they believe gravity is in the atmosphere pushing thing to the surface.

The general findings of this study were that children of all age levels were able to verbalize facts about the earth's shape, position and gravity; however, upon further probing many showed mixed understanding and commitment to these verbalizations.

TABLE VII

EARTH NOTION LEVEL FREQUENCY DISTRIBUTION
BY AGE AND SEX

		NOTION LEVELS					
Grade	Sex	1	2	3	4	5	Total
K	M	5	1	1	4	5	11
	F	10		1			11
2	M	3	1	2	5		11
	F	8	1		4		13
4	M			2	9	1	12
	F			4	5	1	10
6	M		2	1	4	3	10
	F		4	2	7		13
N/Notion		26	9	13	38	5	91
N/Sex/	M	8	4	6	22	4	44
Notion	F	18	5	7	16	1	47

Only 5 of the 91 students interviewed failed to say the earth was round like a ball or some other spherical object. When asked why they believe the earth is shaped this way, it was clear they did not all conceive of the spherical earth in the same way. Here are some of their responses.

1. (Kindergarten Boy) "I saw it when it was dark up in the sky. There are two; one is flat and the one up in the sky is round. We're on the flat one."
2. (Second Grade Girl) "Because when you look up in the sky it looks like this round ball all around us." (See Figure 3.)
3. (Fourth Grade Girl) "Probably so if you went too far you wouldn't fall off. A long time ago a man named Columbus went to sail the seas and he went to prove the earth was round. He succeeded and then everybody knew it was round."
4. (Sixth Grade Boy) "Because it's not flat. Back in the old days they thought it was flat. But it's not. There's no way."

[Why not?]

"Because, it's just round. I don't know why."

[How did you come to know it was round?]

"I don't know. I just thought it was round."

[Does it look round?]

"From space it does and it turns." (See Figure 4.)

In his drawing we can see other celestial bodies are drawn above the earth. When questioned further, he said there were planets below the earth but no space. He also indicates in later drawings that only things on top of the earth stay. Others fall off.

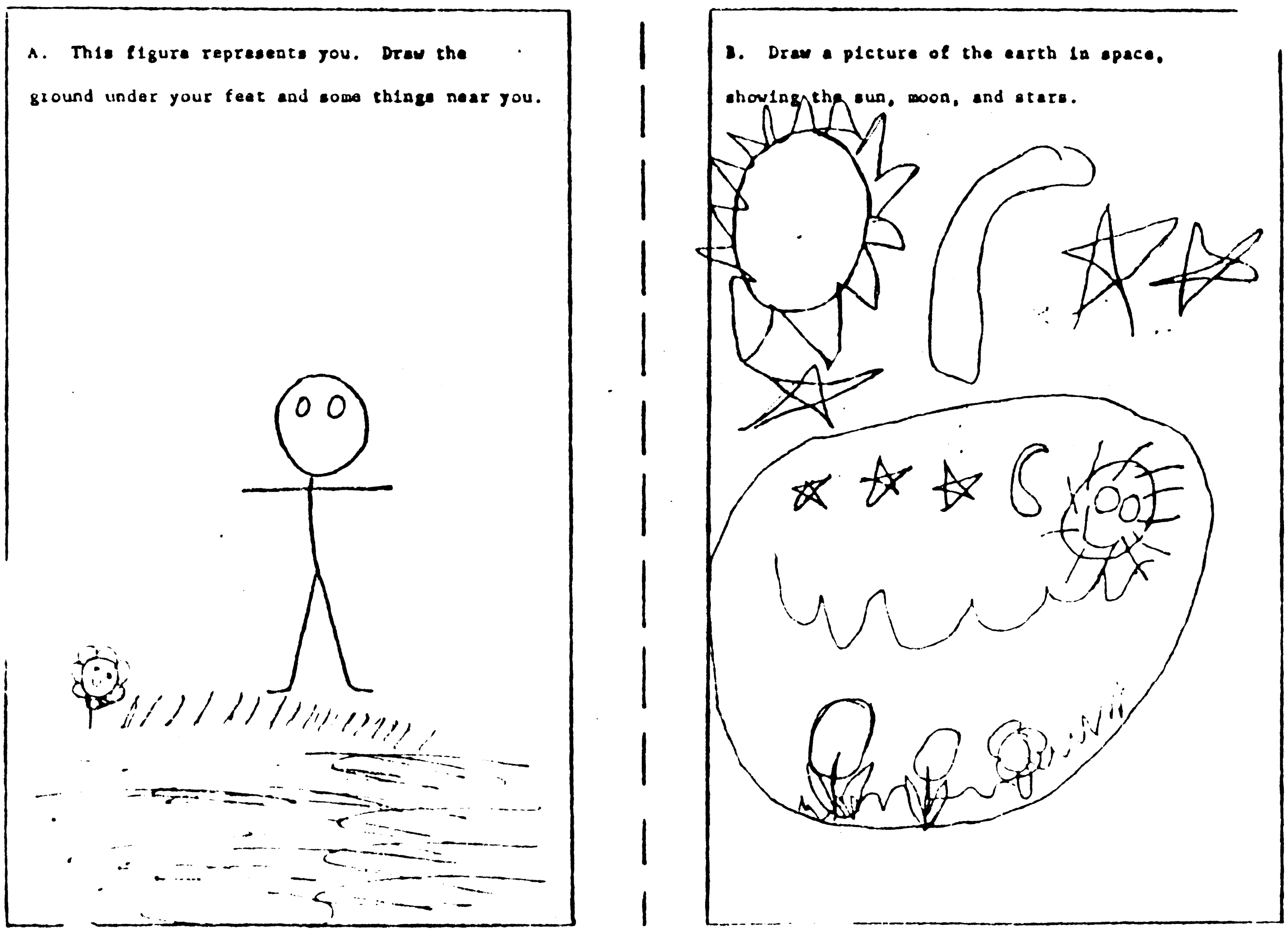


Figure 3. Drawing of Earth in Space by Second Grader

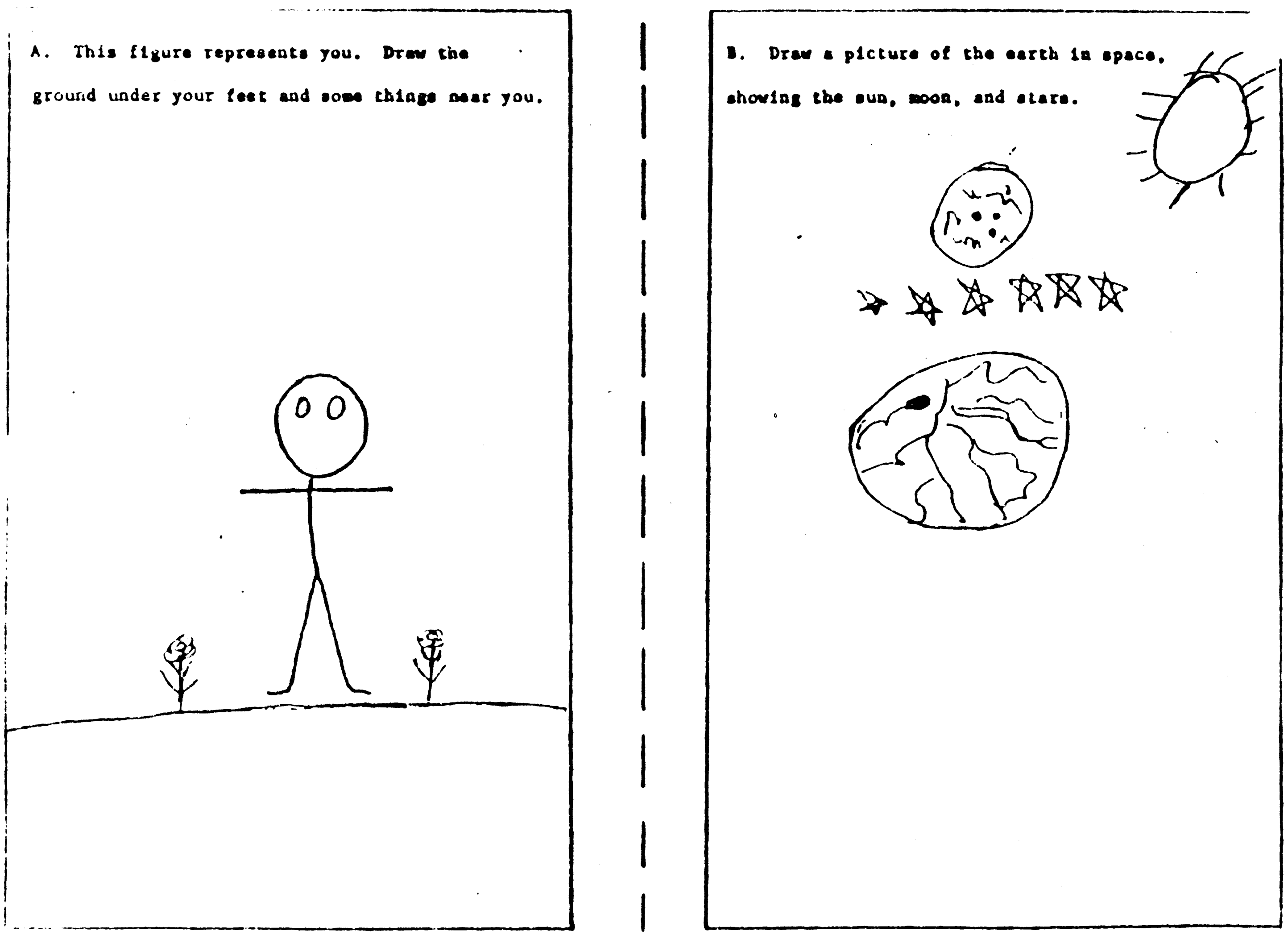


Figure 4. Drawing of Earth in Space by Sixth Grader

The question of where we must look to see the earth as well as the explanations for why one drawing shows the earth flat while the other is like a ball were very helpful in singling out children who believe in two earths. These children consistently said we must look up to see the ball shaped earth and the two pictures show the flat land we live on and the ball that is up in space. Some said people could live on the ball while others claim this is impossible. These questions also identified students who think they live inside the earth.

[Where is the earth?]

5. (Kindergarten Boy) "Up there."

[So the earth is up above us?]

"Uh huh."

[It's not down here.]

"Well we're on the earth. It's all around us...We're in the earth but we can get out in a rocket."

[Why does the earth look flat if it's really round?]

6. (Second Grade Girl) "Because it's great big and it's flat here (in the middle)."

[What's up here? (top half of the ball)]

"Sky."

[Where would we be on this ball?]

"Right here." (in the middle)

[Could you stand on the surface?]

"No. We're inside the ball."

7. (Sixth Grade Girl) "The earth is all around you. You can look any direction and see part of the earth...Well the earth it seems

it never ends. Half of the ball, like the land here and the earth is round. So the earth is like this (gestures to show a ball) but the land is flat here."

Responses to questions on gravity were also quite varied. When asked to predict what would happen to water in bottles sitting on the south pole 63 percent of the kindergarten and second grade students said the water would pour out and 33 percent of the fourth and sixth grade students gave a similar response. Many said that you could not stand there and the bottles would fall either into space or to the ground below. Most curious though were the children who claimed the water would pour out but gravity would hold people and bottles on the surface.

The problem of rocks falling at several different places on the surface of the earth again helped differentiate children's overall understanding of shape and gravity.

8. (Second Grade Boy) "Well to a big island there. They end up on a big island."

[The rocks would stay there?]

"Yes, but we wouldn't, we'd go off in space." (See Figure 5.)

[Why would we go into space but the rocks would go down?]

"Because the rocks are on earth and there's 'hazium' or whatever you call that that keeps you down on the earth."

[So this rock would go down but the person would go up. Why wouldn't the rock go up?]

"Maybe it would."

[Why wouldn't the person go down?]

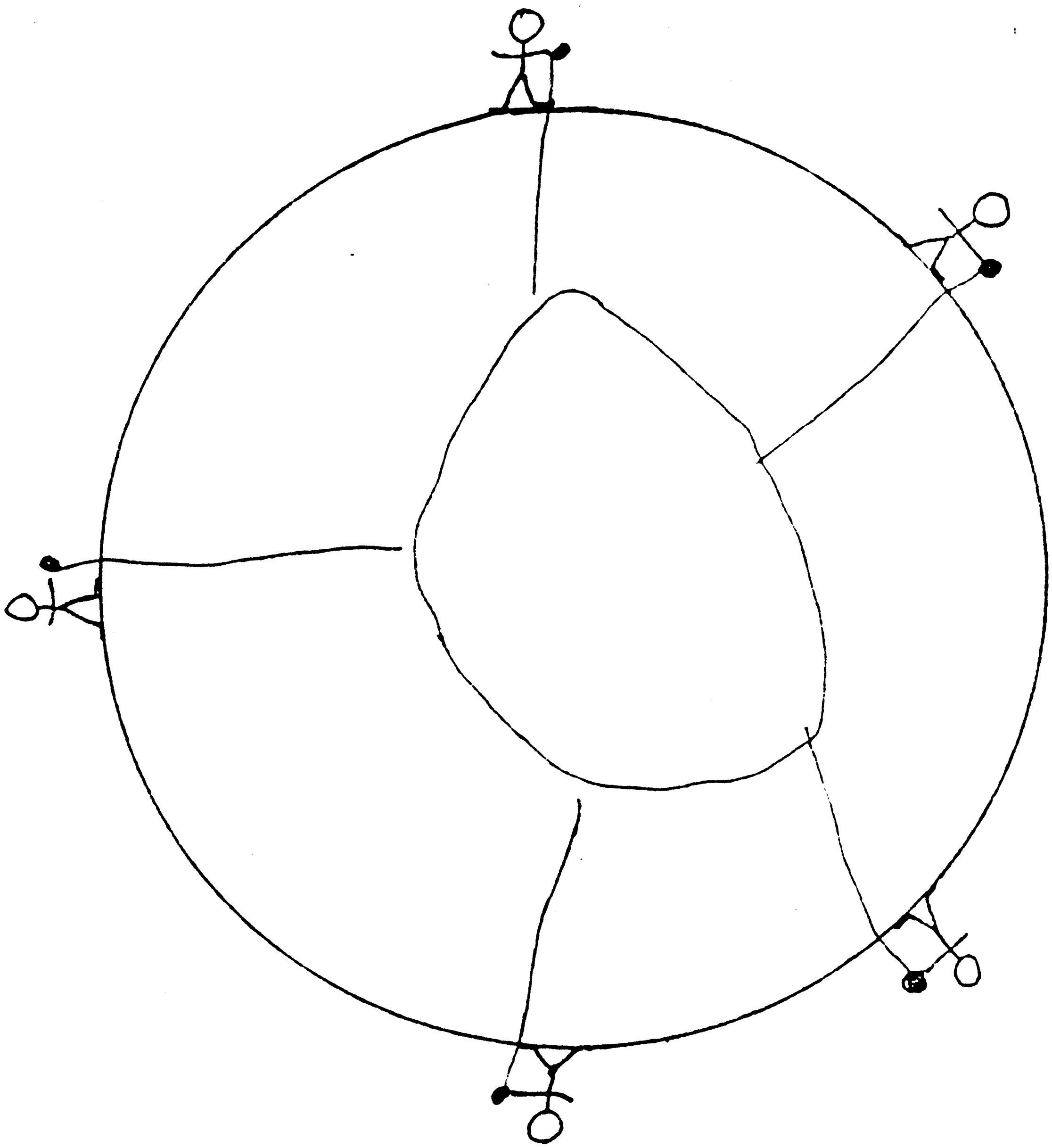


Figure 5. Drawing by a Second Grader of Rocks Falling on the Earth

"Because it's space and has no helium to keep you down. What do you call that. That thing that makes you stay down on the earth? I can't remember that word."

[Gravity?]

"Yea, gravity!...Really the people and the rocks would both go out in space."

9. (Kindergarten Boy) "They would drop on the ground."

[Will they stay there?]

"Yea."

[They won't roll off?]

"No."

[Why not?]

"Because of gravity."

Questions about objects falling inside the earth gave a final distinction between level 4 and level 5. Eight students predicted that rocks would fall to the center of the earth and only five of those understood that the reason was because the pull of gravity is strongest toward the center. Most students (66%) predicted the rock in "drop through" would either drop down and out the other side or down and loop back up to the other side.

The last question asking students whether rocks fall to the center (tunnel A) or to the South Pole (tunnel B) was difficult to interpret. Fifty percent of the sample population correctly predicted that the rock would go to the center, however, their rationale was often confusing.

10. (Kindergarten Girl) "His arm is closer to "A" and the rock goes straight down."

11. (Fourth Grade Boy) " 'A' because rocks can't curve."

12. (Second Grade Boy) " 'A' because it will hit that point and roll down there."

Finally children were asked where they learned about the earth's shape and how things fall. The highest frequency of kindergarten children gave home as their major source of information but most second, fourth and sixth graders gave school as their primary source.

A tally for each parent and teacher survey question is also included in Appendix E.

CHAPTER V

CONCLUSIONS

Summary

The problem in this study was the identification of earth notions held by elementary students in a rural Oklahoma community and some of the significant independent variables related to development of these earth notions. Using the structured individual interview procedures suggested in previous studies on earth notion, the writer was able to identify and categorize the earth notions of kindergarten, second fourth and sixth grade students. Results of these interviews support the findings of past research. Children in Oklahoma hold generally the same notions of earth as did children in other studies. Surprisingly though, the distribution in the Oklahoma sample was skewed more toward upper notion levels than were children studied in previous research. However, as was pointed out by Sneider and Pulos in the comparison of their results with previous studies, interpretation of the results must not overlook possible discrepancies in interviewer rating criteria. Other explanations for the overall higher ranking of Oklahoma students may be greater awareness due to current events, such as Space Shuttle flights, or perhaps greater spatial perceptual ability of rural students. The preinterview activities conducted by the author to insure better rapport with subjects may also have improved the responses in the Oklahoma sample.

A number of independent variables have been included in past research to help account for the variance in earth notions held by children and have been found to be significantly related. Of these, age, sex, grade, parents' years of education, achievement scores, verbal ability, spatial ability were included in this study in an effort to further validate these findings. Although support was found for the significance of all of the above sources of variance, verbal ability, spatial ability, achievement scores, and sex were determined to be the more reliable predictors of notion level. Other studies had not looked extensively into the sources of information in the home and school contributing to earth notion (with exception of Mali and Howe). However, both were found to be statistically significant in this study. The parent and teacher surveys were successful in identifying important experiences children have been exposed to, but further development and refinement of these instruments will be needed in future studies.

Implications

The results of this study indicate that there is a degree of readiness for earth notion subject matter as early as kindergarten. In the kindergarten sample, 18 percent were classified at level 4 and another 13.6 percent held notions 2 or 3. Of those kindergarteners who demonstrated a relatively high understanding of earth concepts, most had been exposed to a wide variety of experiences through the home, including travel, books, science museums and especially discussions with parents. The experience of this author as an early childhood educator has been that the natural curiosity of the young child about the world around him makes him an intrinsically motivated scientist. The adult's role is that of facilitator of experiences. If the young child is to develop preconceptions about the earth that will enable him to accommodate new information as later formal instruction begins, he must have the opportunity to experience, first hand, changes in visual perspectives, to manipulate real objects, and to develop his verbal skills through oral language. Children must be exposed to many concrete experiences before being introduced to symbolic representations of the concrete world. As young children begin to question the cause and effect relationships in their physical world, it is important to avoid explanations that may promote distortions in the child's concepts.

Many experiences, although intended to clarify meaning and further children's understanding, may in fact further elaborate their misconception. The sixth graders in this study may be an example of such a case. Twenty-six percent of the sixth graders interviewed believe we live inside the earth (level II). These students were generally average in verbal ability and achievement scores. How did these preconceptions develop? These students had received formal instruction beginning in second grade and yet their understanding is seen as conceptually naive when compared with external criteria. One surprising explanation for this anomoly came during a discussion about why they believe we live on a flat surface in the middle of the sphere. Several students related their experience in fifth grade of visiting a planetarium. They talked about how the sky looked curved and how we were in the middle. It seems very possible that the root of their alternative framework was the experience of seeing the sky projected on a curved ceiling with a flat floor at the planetarium. We can see here the importance of exposing these ideas before they become stable and the foundation on which the child attempts to assimilate later learning. Although this explanation is yet untested, the implications should be of special interest to planetarium directors and all instructors alike.

The emphasis in the earth notion research to date has been placed primarily on understanding the development of children's concepts, improving methods for exposing their ideas and developing better instructional strategies. The importance of the earth concept itself, although it may have been implied, has been a secondary emphasis. As advances in technology continue and as natural resources become more and more a limiting factor, the significance of this basic concept is increasingly clear.

Children develop basic attitudes at a young age, and when those attitudes are guided by major misconceptions, the effect may be carried into adulthood where decision making is influenced. The research reported here supports previous research showing the prevalence of alternative frameworks in children of many ages even after receiving formal instruction. Although it has not been the purpose of this study to investigate children's attitudes toward the earth, the need for such research is evident.

Recommendations

A number of potential research problems surfaced as a result of this study. A list of recommendations for further study, as well as recommendations for classroom application, follows.

1. As mentioned earlier, refinement of the parent and teacher surveys would be helpful in creating a clearer picture of the influence of cultural experiences. Perhaps personal interviews could be used with parents. Also in the future a multiple correlation for school experiences (this study only looked at a multiple correlation for home) is suggested.
2. There are a number of other Piagetian tasks, such as the three mountain tasks, that could be used to get a better understanding of cognitive level.
3. During interviews with kindergarten and second grade children, the researcher detected the influence of older siblings on younger children's level of understanding. This source of variance needs further investigation either as part of the earth interview or as part of the parent survey.
4. Although true longitudinal studies are difficult, they should be attempted. In a small school system longitudinal studies may be more feasible. Cross-age studies have been done previously, but a longitudinal approach could prove very enlightening.
5. It has been suggested that the interview itself may be instructional. Therefore, an experimental design with an interview followed by another interview one to two months later could offer

important suggestions for development of improved instructional designs.

6. A textbook review to identify material which could aid or cause distortion of children's concepts is needed. Textbook authors and curriculum planners need to consider the major misconceptions children have about scientific concepts when developing curriculum materials. Teachers' guides need to include ideas for sequential concrete experiences for teaching concepts such as earth's shape, gravity and position in space.

7. It would be beneficial to have discrepant event activities included in curriculum to create cognitive disonance and stimulate children's accommodation of a more mature earth concept.

8. Classroom teachers must become aware of children's preconceptions before beginning any instructional unit. They cannot assume that because a concept was covered last year that the child has accommodated the necessary learning free of major misconceptions. It is essential to begin with the child's present conception, and this requires more listening on the part of teachers to assess this level. Correct answers on paper and pencil tasks are not always the best measure of the child's true level of understanding. As suggested in other studies, the Piagetian clinical interview method should be utilized more often by classroom teachers to assess student progress.

9. Two students expressed a belief that gravity is in the atmosphere pushing things down. Additional questions need to be included in future interviews to explore this preconception. It is very

possible that other level 4 children may have held this idea but it was not exposed in this study.

10. Future research must not overlook the kindergarten age group. Other studies found second graders with definite alternative frameworks already in place. These ideas certainly had their roots in much earlier experiences. Any real attempt to understand the development of the earth concept and its influencing factors should begin before major preconceptions develop. Developing a rich base of experiences at the primary and preschool level will certainly enhance the growth of preconceptions compatible with accommodation of later earth concepts.
11. The curious question of the effect of trips to the planetarium on children's notions of earth will require further study before any real conclusions can be drawn. A pre-interview followed by a planetarium trip and post interview would be a good place to start. Perhaps one group might have some prepatory remarks prior to the planetarium show to sensitize them to the discrepancy in their perception while another group would receive no explanation.
12. Finally children's attitudes toward conservation of resources, the biosphere or other environmental issues could be correlated with earth notion. Would children with less egocentric views of the earth have more positive attitudes toward conservation of natural resources? If so, this would add real support to the importance of developing level V earth notions in students. In addition the earth concept's place in research and curriculum development, especially in environmental education, would be given appropriate emphasis.

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APPENDIX A

EARTH NOTION INTERVIEW FORMAT

Children's Concepts of the Earth

Interview Format No. 2--Revised February 4, 1979

Before the interview, assemble the following materials:

a. A globe of the earth with a cardboard stick figure which has sticky feet, allowing it to be attached to the top, bottom, or side of the globe.

b. Two styrofoam balls, one with a hole bored all the way through as in drawing No. 4 of the student's booklet, the other with two tunnels bored as in drawing No. 6.

c. One copy of the student's booklet to be handed to the student one page at a time during the interview.

d. A crayon or felt marking pen for the student to use, a pen or pencil for the interviewer for keeping notes, and a pencil that can be inserted in the balls to demonstrate the length and direction of the holes.

After each response, record what the student said, or briefly describe what the student drew.

Part I: Open-Ended Questions

1. What is your name? ______________________ What grade are you in? ___ What is your age in years? ___ and months? ___

2. (Fold sheet No. 1 in half, placing part A in front of the student.) This stick figure is you. Draw the ground under your feet and some things near you.

   ____

   ____

3. (Flip sheet No. 1 over so student sees side B.) Draw the earth in space, showing the sun, moon, and stars.

   ____

   ____

4. What is the shape of the earth in your picture? (If student says "round," ask if it is round like a record or pancake or something else.

   ____

   ____

5. Why do you believe the earth is that shape?

____

____

6. Point to show which way we must look to see the earth.

____

____

7. (Open sheet No. 1, showing student sides A and B side-by-side.) In the first picture you drew the ground flat. In this picture the earth is shaped like a (ball, or whatever the student called it). Can you explain why it looks flat here and like a (ball) there?

____

____

8. What must you do to see the earth like a (ball)?

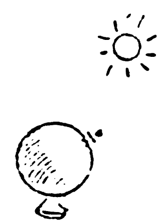
____

____

Part II: Questions About Globes,

Balls, and Pictures

10. (Place the globe in front of the student.) This globe represents the earth. Here you are in California. (Place figure on California.) Pretend that this ball is the sun. (Hand a styrofoam ball to the student.) I want you to use the sun and earth model to show me why we have night and day.



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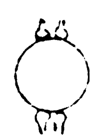
____

11. (Give the student sheet No. 2.) This is a picture of the earth. These two bottles (pointing to bottles at top of page) are right next to you while you are standing on this part of the earth (stick figure to Northern Canada). One bottle is closed and half-full. The other bottle is open and empty. Take the crayon and draw some water in the open bottle so it has just as much water as the other bottle. (The student draws water in the bottle.)

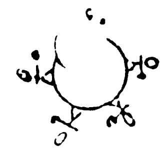
Now suppose you travel with your two bottles to this part of the world (remove figure from Canada and place on Chile), and place the two bottles next to you. Think about the way the water will be in the bottles on this part of the earth (point to bottles



at the bottom of the page). Draw some water showing the way it would be on this part of the earth.

---

12. (Give the student sheet No. 3.) This is also a drawing of the earth. You have traveled to four different places (point to stick figures). In each place you have dropped a rock. For each rock draw a line showing how the rock will fall when you let go. (If the child draws lines to the surface of the earth, point to where the line ends and ask) Will the rock stay at this spot?



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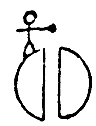
13. (Give the student sheet No. 4.) My pal Superman dug a hole all the way through the earth and lined it with a strong steel tube. If you look through the hole, you can see all the way to the other side of the earth. (Take styrofoam ball and demonstrate by pushing pencil all the through the hole.) Now suppose you stand here (point to stick figure) and drop a rock. Draw a line showing where the rock would fall and tell me where it would finally end up.



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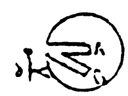
14. (Give the student sheet No. 5.) Here is the same problem that you just solved (point to top picture). Below are five answers that were given by five different students. Which picture shows the way you think the rock will really move? Why did you pick that one? What's wrong with the other answers?

---

15. (Give the student sheet No. 6.) This picture shows the earth with two tunnels which Superman was nice enough to dig for us. Tunnel A goes to the center of the earth. (Demonstrate with the second styrofoam ball and a pencil.) Tunnel B goes toward the South Pole (show tunnel B with a pencil). Pretend that you stand on this part of the earth (point to stick figure) and drop a rock. Draw a line which shows where the rock will go.



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16. One student who answered this question said that the rock will go in tunnel A because all things fall to the center of the earth. Another student said it will go in tunnel B since that is closer to the South Pole. Who is right? Why?

____

____

17. Where did you learn about the shape of the earth and how things fall? (Use back of page if necessary.)

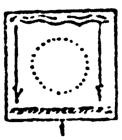
____

____

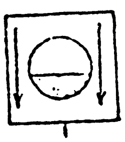
____

Analysis

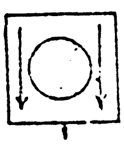
The following categories are from Nussbaum's recent article published in Science Education ("Children's Conceptions of the Earth as a Cosmic Body: A Cross Age Study," Vol. 63, No. 1, 1979, pp. 83-93):



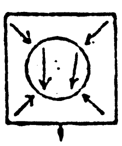
Notion No. 1: "The earth is flat."



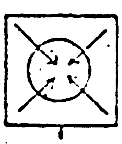
Notion No. 2: "The earth is shaped like a ball. We live inside of the ball."



Notion No. 3: "The earth is shaped like a ball. We live on top of the ball."



Notion No. 4: "The earth is shaped like a ball. We live all around the ball. Things fall to the surface of the earth."



Notion No. 5: "The earth is shaped like a ball. We live all around the ball. Things fall to the center of the earth."

Which notion, or transition between notions, best characterizes this student's responses? On the following lines summarize the evidence for this notion and against earlier or later notions.

____

____

____

____

____

____

____

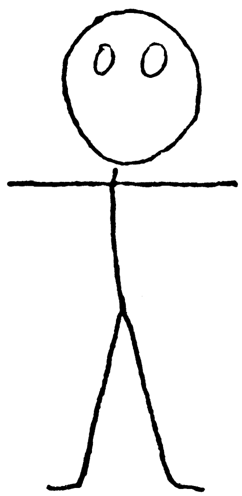
____

____

(Continue on back of sheet if necessary.)

Student's Name ____________________ Notion No. ________________

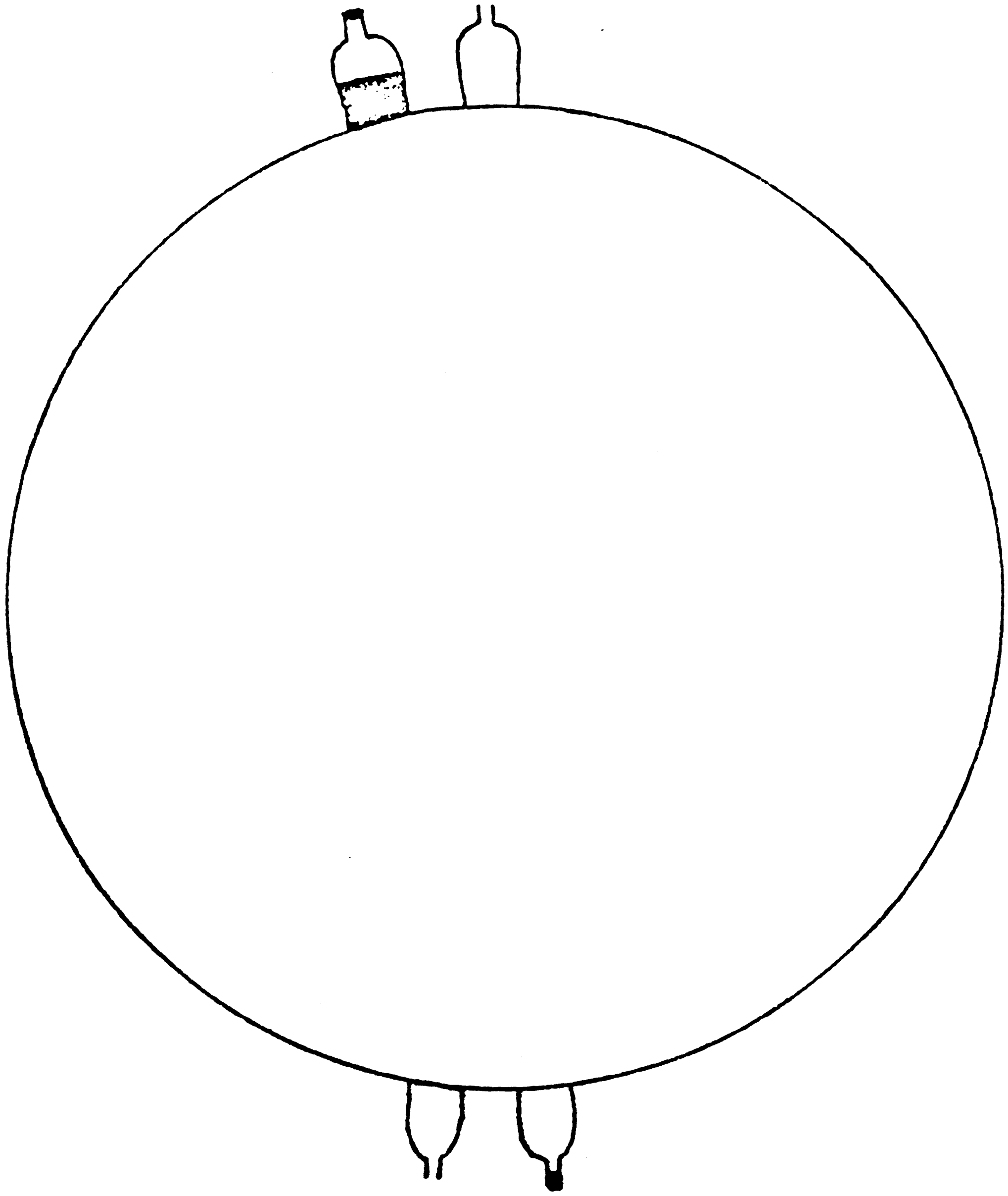
A. This figure represents you. Draw the ground under your feet and some things near you.



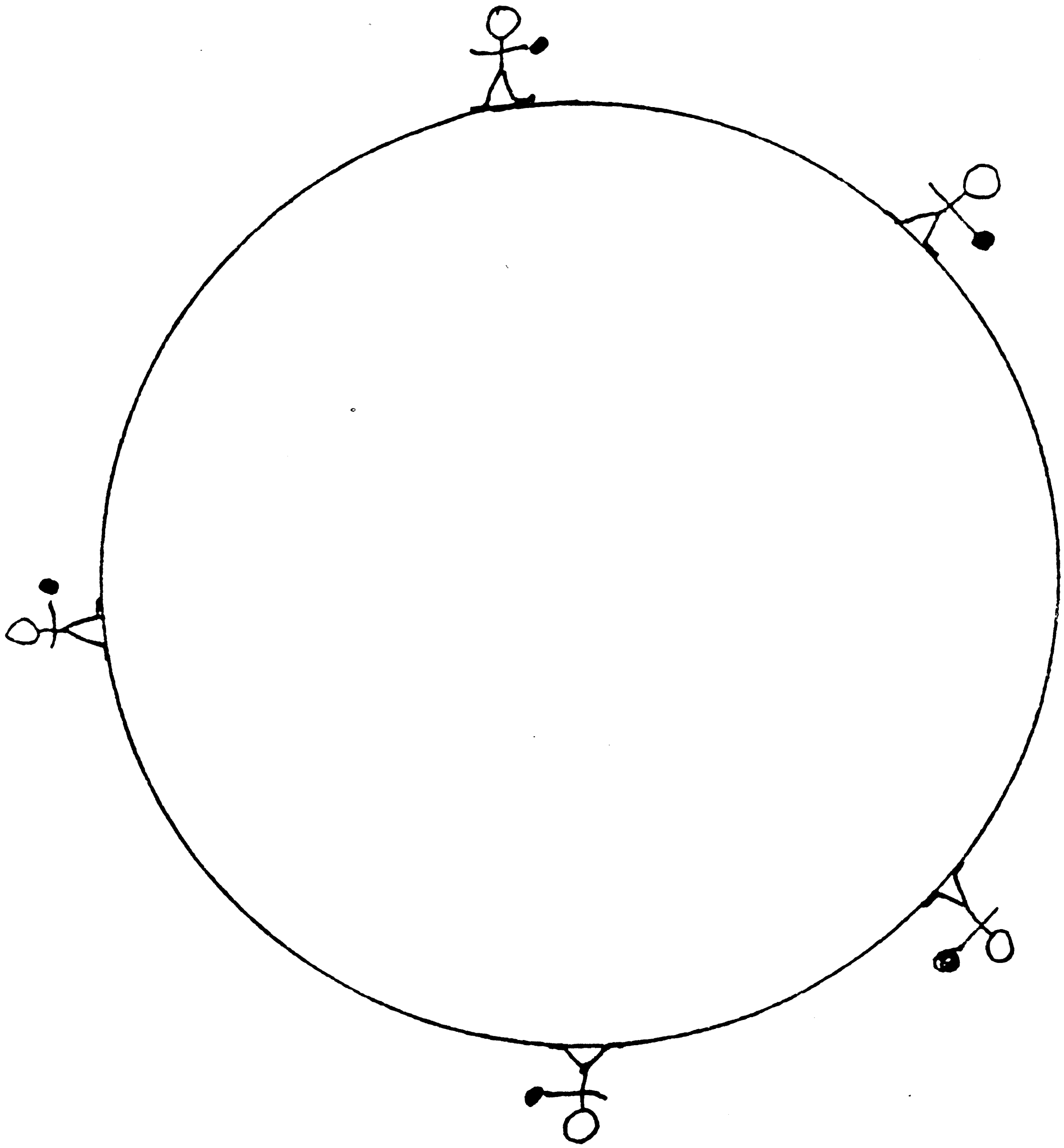
B. Draw a picture of the earth in space, showing the sun, moon, and stars.

Sheet No. 1

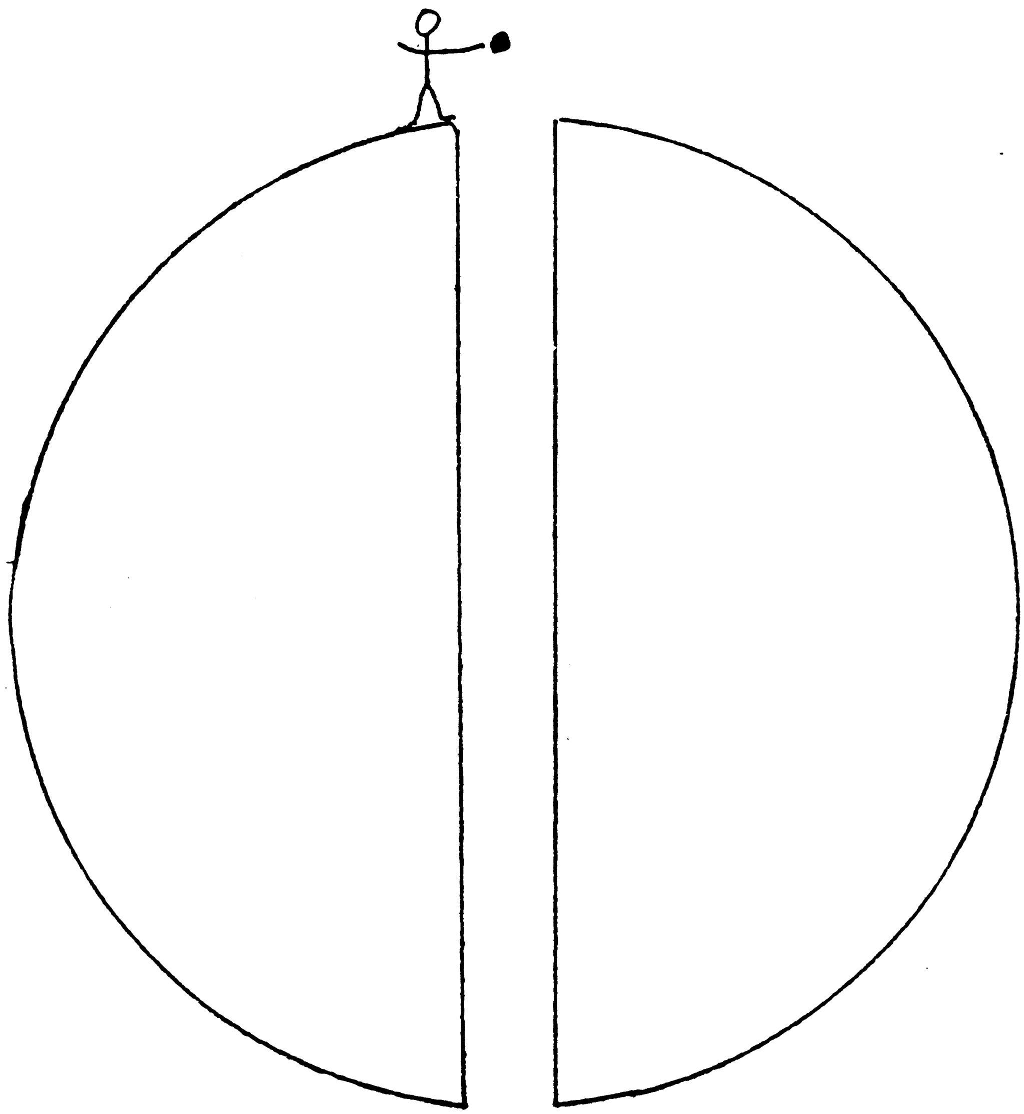
Sheet No. 2



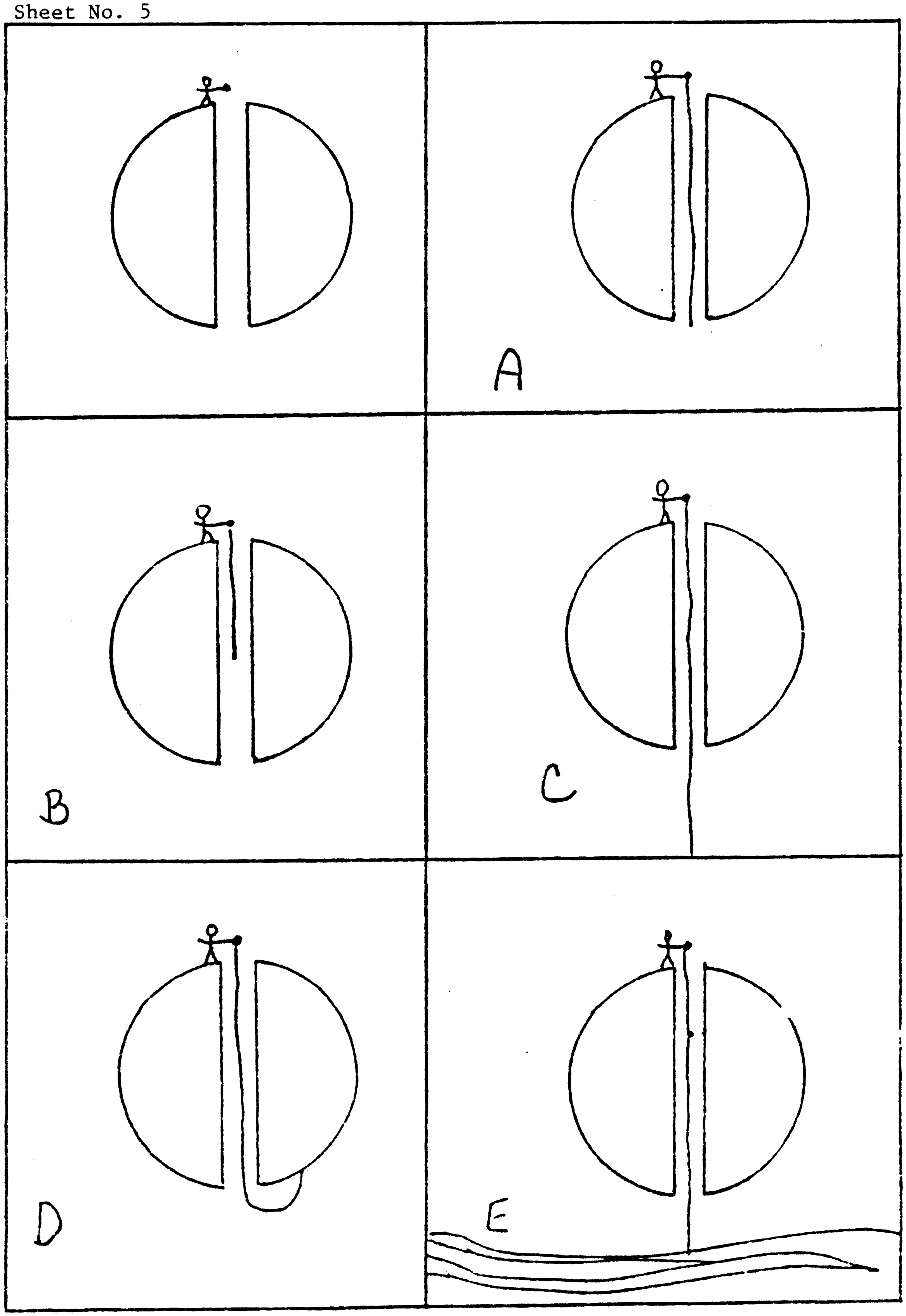
Sheet No. 3



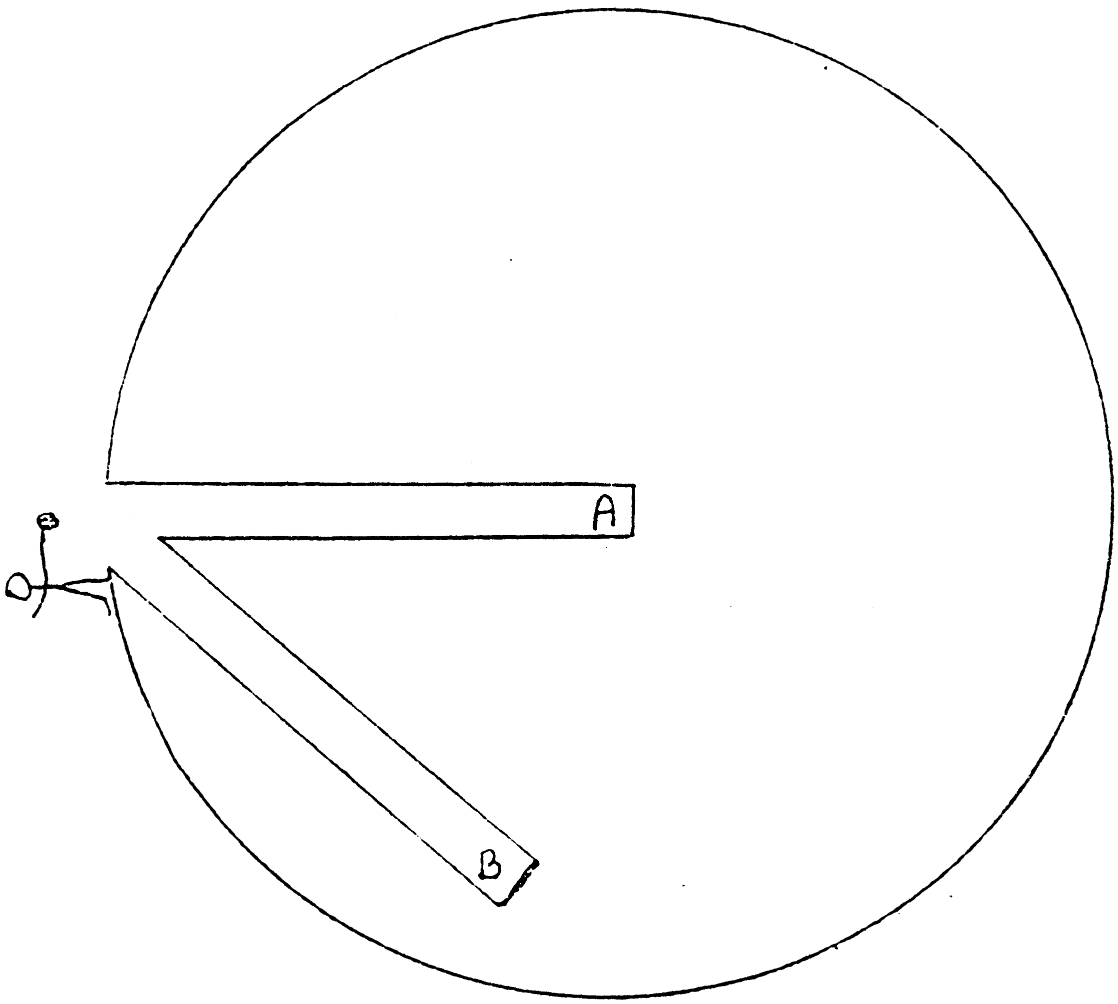
Sheet No. 4



Sheet No. 5



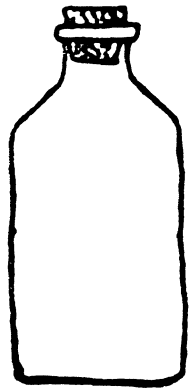
Sheet No. 6



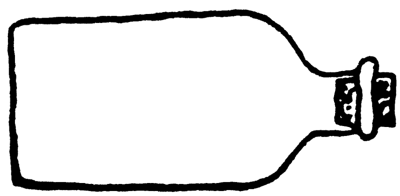
APPENDIX B

WATER LEVEL TASK DRAWING

Water Level Task



Fold



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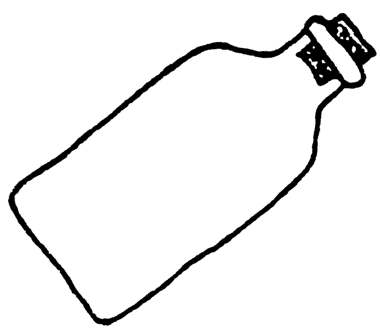

APPENDIX C

VERBAL OPPOSITES WORD LIST

3. Pictorial Opposites

Score................................

(See pages 25-27 of Handbook and pages 19-36 of Pictorial Material)

a. Flower pot	1 ✓	5. Truck	1 2 3	11. Rain	1 2 3
b. Door	1 2 ✓	6. Kite	1 2 3 4	12. Smiling boy	1 2 3
1. Basket	1 2	7. Cat	1 2 3	13. Hand	1 2 3 4 5
2. Wagon	1 2 3	8. Toys	1 2 3	14. Vase	1 2 3
3. Tree	1 2 3 4	9. Coat	1 2 3	15. Table and ball	1 2 3
4. Boy's head	1 2 3	10. Auto	1 2 3 4	16. Fallen tree	1 2 3

---

4. Verbal Opposites

Score................................

(See pages 27-29 of Handbook)

Sample: day–

1. boy
2. front
3. up
4. brother
5. wet
6. dirty
7. young
8. hot
9. dead
10. crooked
25. asleep
26. come
27. add
28. laugh
29. daughter
30. strong
31. narrow
32. false
33. love
34. remember
49. dangerous
50. victory
51. begin
52. deep
53. difficult
54. lengthen
55. costly
56. succeed
57. imprisoned
58. entrance
73. create
74. passive
75. autocracy
76. reject
77. loiter
78. ignorant
79. diminish
80. gradual
81. abstract
82. expand

11. early ....
12. sour ....
13. shut ....
14. empty ....
15. noisy ....
16. tight ....
17. lost ....
18. north ....
19. sick ....
20. off ....
21. black ....
22. heavy ....
23. near ....
24. smooth ....
35. pretty ....
36. stale ....
37. blond ....
38. absent ....
39. same ....
40. raw ....
41. cruel ....
42. after ....
43. sharp ....
44. evening ....
45. friend ....
46. multiply ....
47. wild ....
48. public ....
59. falsehood ....
60. lend ....
61. timid ....
62. profit ....
63. former ....
64. vertical ....
65. maximum ....
66. complex ....
67. bless ....
68. unite ....
69. convex ....
70. asset ....
71. inferior ....
72. optimistic ....
83. discord ....
84. epilogue ....
85. superfluous ....
86. naive ....
87. anabolism ....
88. cause ....
89. tentative ....
90. intermittent ....
91. synthesis ....
92. clergy ....
93. diurnal ....
94. magnify ....
95. corpulent ....
96. ecstasy ....

APPENDIX D

CULTURAL SOURCES OF INFORMATION SURVEY: SCHOOL AND HOME

Dear Teacher:

Recently students in your school participated in a project aimed at identifying their notions of earth. Three aspects of the earth notion were investigated: (1) earth's shape, (2) earth's gravity, and (3) earth's position in space. Children's notions of earth develop as a result of maturation and experience. The school, of course, is one cultural source of information. The following questions are designed to identify sources of information in the school that contribute to students' understanding of the earth.

After completing the questionnaire, please return it to me in the envelope provided. Thank you for your time and cooperation.

Sincerely,

F. Fenderson

Frances Fenderson

Cultural Sources of Information/School

1. What grade do you teach? ____________

2. How many years have you taught this grade level? __________

3. How many years have you taught in this school system? ____________

4. How much time was spent in your classroom this year on earth notion concepts?

   A. 30 min. B. 60 min. C. 90 min. D. More than 90 min.

5. During which quarter(s) did you include earth notion concepts as part of your curriculum?

   A. 1st B. 2nd C. 3rd D. 4th

6. The concepts of earth's shape, gravity, and position in space are included in the study of which subject(s) in your class?

   A. Science B. History C. Geography D. Social Studies
   E. Math F. Language Arts

Using a 1-5 scale, answer the following questions.

	Time Spent				
	Little				Much
7. How much time do students spend using globes in your class?	1	2	3	4	5
8. How often do the terms (earth, biosphere, gravity, sun, moon, day, night, rotation, etc.) appear in your instructional content (discussions, texts, etc.)?	1	2	3	4	5
9. How much time has your class spent visiting science and space museums such as the Omniplex?	1	2	3	4	5
10. How often have you talked with your class about how the earth looks at high elevations?	1	2	3	4	5
11. How frequently has your class watched television programs such as:					
a. Nova	1	2	3	4	5
b. NASA programs	1	2	3	4	5
c. Karl Sagan programs	1	2	3	4	5
d. 321 Contact	1	2	3	4	5
e. Other educational programs (films) related to earth	1	2	3	4	5

Dear Parents:

Recently your child participated in a project aimed at identifying his/her notion of earth. Three aspects of the earth notion were investigated: Earth as (1) a spherical body, (2) surrounded by space, and (3) with objects falling toward the center of the sphere. Children's notions of earth develop as a result of both maturation and experiences. The home as well as the school offer such experiences. The following questions are designed to identify sources of information in the home that have contributed to your child's understanding of earth. Your participation will be very helpful in improving teaching strategies and curriculum development.

Please respond to the following questions indicating the "amount of time spent" in each experience on a scale of 1-5 (where 1 is little or no time spent and 5 is a great deal of time). All responses will be kept completely confidential.

After completing the questionnaire, please return it to me in the envelope provided. Thank you for your time and cooperation.

Sincerely,

Frances Fenderson

Background Information

Mother's occupation ______________________________

Father's occupation ______________________________

Highest educational level completed:

Mother ___________

Father ___________

Approximate yearly income (optional) _______________

Sources of Information in the Home

		Time Spent				
		Little				Much
1.	How much time has your child spent flying in an airplane where he/she could see the earth from far away?	1	2	3	4	5
2.	Has your child spent time at the top of a tall mountain where he/she could see a large part of the earth?	1	2	3	4	5
3.	How often do you talk with your child about how the earth looks at high elevations?	1	2	3	4	5
4.	How often has your child been to the planetarium?	1	2	3	4	5
5.	How much time has your child spent at science and space museums such as the Omniplex?	1	2	3	4	5
6.	How frequently does your child watch the following television programs:					
	a. Nova	1	2	3	4	5
	b. NASA programs	1	2	3	4	5
	c. Karl Sagan programs	1	2	3	4	5
	d. 321 Contact	1	2	3	4	5
	e. Other educational programs related to earth	1	2	3	4	5
7.	How frequently do you discuss these programs with your child?	1	2	3	4	5
8.	How frequently does your child play games in which he/she might observe the effects of gravity (e.g., basketball, jacks, etc.)?	1	2	3	4	5

9. How much time does your child spend reading or looking at books in which the earth's shape, gravity, or position in space are discussed or pictured? 1 2 3 4 5

10. How frequently has your child used a telescope? 1 2 3 4 5

11. How much time does your child spend locating places on or playing with a globe in your home? 1 2 3 4 5

12. How often have you talked with your child about the cause of day and night or seasons? 1 2 3 4 5

13. How much time have you spent discussing the effects of gravity with your child? 1 2 3 4 5

14. How frequently have you and your child talked about the earth's shape? 1 2 3 4 5

15. How often do you and your child discuss the earth's relationship in space to the sun, moon, or stars? 1 2 3 4 5

Please list any other experiences your child has had that may contribute to his/her understanding of earth's shape, gravity, or position in space.

APPENDIX E

FREQUENCY COUNT OF RESPONSES

TO SURVEY QUESTIONS

Parent Survey: Tallies by Grade and Total

Sources of Information in the Home

Time Spent: Little (1) — Much (5)

1. How much time has your child spent flying in an airplane where he/she could see the earth from far away?

	1	2	3	4	5	Mean
K	11	2	1	-	-	1.30
2	15	-	-	-	1	1.25
4	9	1	-	-	-	1.10
6	12	2	1	-	-	1.27
Total	47	5	2	0	1	1.24

2. Has your child spent time at the top of a tall mountain where he/she could see a large part of the earth?

	1	2	3	4	5	Mean
K	8	5	1	-	-	1.50
2	10	2	2	1	1	1.80
4	4	4	2	-	-	1.80
6	7	4	1	2	1	2.07
Total	29	15	6	3	2	1.80

3. How often do you talk with your child about how the earth looks at high elevations?

	1	2	3	4	5	Mean
K	10	3	1	-	-	1.20
2	9	4	1	2	-	1.75
4	6	3	1	-	-	1.50
6	11	1	2	1	-	1.53
Total	36	11	5	3	0	1.55

4. How often has your child been to the planetarium?

	1	2	3	4	5	Mean
K	12	-	1	1	-	1.36
2	14	1	1	-	-	1.19
4	7	2	-	1	-	1.50
6	10	5	-	1	-	1.60
Total	43	8	2	3	0	1.40

5. How much time has your child spent at science and space museums such as the Omniplex?

	1	2	3	4	5	Mean
K	12	-	1	1	-	1.36
2	14	1	1	-	-	1.19
4	7	2	-	1	-	1.50
6	10	5	-	1	-	1.60
Total	43	8	2	3	0	1.40

6. How frequently does your child watch the following television programs:

a. Nova

	1	2	3	4	5	Mean
K	11	2	1	-	-	1.36
2	9	4	2	-	1	1.75
4	6	2	1	-	1	1.80
6	12	2	1	-	-	1.27
Total	38	10	5	0	2	1.50

b. NASA programs	K	12	2	-	-	-	1.14
	2	10	4	2	-	-	1.50
	4	6	2	2	-	-	1.60
	6	13	-	2	-	-	1.27
	Total	41	8	6	0	0	1.36
c. Karl Sagan programs	K	14	-	-	-	-	1.00
	2	14	2	-	-	-	1.12
	4	10	-	-	-	-	1.00
	6	14	-	1	-	-	1.33
	Total	52	2	1	0	0	1.07
d. 321 Contact	K	12	-	-	1	1	1.50
	2	13	2	1	-	-	1.25
	4	8	-	1	-	1	1.50
	6	13	-	2	-	-	1.27
	Total	46	2	4	1	2	1.38
e. Other educational programs related to earth	K	10	3	-	1	-	1.43
	2	9	6	-	-	1	1.62
	4	7	2	-	-	1	1.60
	6	2	1	2	-	-	1.33
	Total	38	12	2	1	2	1.50

		1	2	3	4	5	Mean
7. How frequently do you discuss these programs with your child?	K	10	1	2	-	-	1.38
	2	8	3	3	-	1	1.87
	4	6	-	1	2	-	1.89
	6	8	4	3	-	-	1.67
	Total	32	8	9	2	1	1.69

		1	2	3	4	5	Mean
8. How frequently does your child play games in which he/she might observe the effects of gravity (e.g., basketball, jacks, etc.)?	K	2	4	2	-	6	3.30
	2	1	2	7	1	5	3.44
	4	-	1	1	3	5	4.20
	6	3	-	4	4	4	3.40
	Total	6	7	14	8	20	3.53

		1	2	3	4	5	Mean
9. How much time does your child spend reading or looking at books in which the earth's shape, gravity, or position in space are discussed or pictured?	K	6	6	1	-	-	1.60
	2	6	3	3	1	2	2.33
	4	1	3	3	1	1	2.77
	6	6	7	1	1	-	2.20
	Total	19	19	8	3	3	2.08

		1	2	3	4	5	Mean
10. How frequently has your child used a telescope?	K	11	2	-	-	-	1.15
	2	14	1	-	-	-	1.07
	4	6	2	1	-	-	1.44
	6	9	5	1	-	-	1.47
	Total	40	10	2	0	0	1.27

11. How much time does your child spend locating places on or playing with a globe in your home?

	1	2	3	4	5	Mean
K	10	2	1	-	-	1.30
2	11	4	-	-	-	1.27
4	4	1	3	1	-	2.11
6	10	2	2	1	-	1.60
Total	35	9	6	2	0	1.52

12. How often have you talked with your child about the cause of day and night or seasons?

	1	2	3	4	5	Mean
K	3	6	4	-	-	2.08
2	2	7	5	-	1	2.40
4	2	5	2	-	-	2.00
6	7	2	4	2	-	2.07
Total	14	20	15	2	1	2.15

13. How much time have you spent discussing the effects of gravity with your child?

	1	2	3	4	5	Mean
K	10	1	2	-	-	1.38
2	8	3	3	-	1	1.87
4	6	-	1	2	-	1.89
6	8	4	3	-	-	1.67
Total	32	8	9	2	1	1.69

14. How frequently have you and your child talked about the earth's shape?

	1	2	3	4	5	Mean
K	4	6	3	-	-	1.92
2	6	3	5	-	1	2.13
4	4	3	1	1	-	1.89
6	9	4	1	1	-	1.60
Total	23	16	10	2	1	1.88

15. How often do you and your child discuss the earth's relationship in space to the sun, moon, or stars?

	1	2	3	4	5	Mean
K	5	7	-	1	-	1.77
2	7	5	2	-	1	1.87
4	4	2	2	1	-	2.00
6	7	5	3	-	-	1.73
Total	23	19	7	2	1	1.83

Teacher Survey: Tallies

1. What grade do you teach? ________________

2. How many years have you taught this grade level?

   14, 18, 8, 8, 8, 1 Mean 9.5 Mode 8

3. How many years have you taught in this school system?

   14, 21, 7, 10, 14, 3 Mean 11.5 Mode 14

4. How much time was spent in your classroom this year on earth notion concepts?

0.	None	1		
1.	30 min.	1		
2.	60 min.	0	Mean 2.5	Mode 3-4
3.	90 min.	2		
4.	More than 90 min.	2		

5. During which quarter(s) did you include earth notion concepts as part of your curriculum?

a.	1st	1, 1, 0, 0, 1, 0	Mean 0.50	Mode 0-1
b.	2nd	1, 0, 0, 0, 0, 0	Mean 0.17	Mode 0
c.	3rd	0, 1, 1, 0, 1, 1	Mean 0.50	Mode 0-1
d.	4th	0, 0, 0, 1, 0, 0	Mean 0.17	Mode 0

6. The concepts of earth's shape, gravity, and position in space are included in the study of which subject(s) in your class?

a.	Science	1, 1, 1, 1, 1, 1	Mean 1.00	Mode 1
b.	History	0, 0, 0, 0, 0, 0	Mean 0.00	Mode 0
c.	Geography	0, 0, 0, 0, 0, 0	Mean 0.00	Mode 0
d.	Social Studies	1, 1, 1, 0, 1, 0	Mean 0.67	Mode 1
e.	Math	0, 0, 0, 0, 0, 0	Mean 0.00	Mode 0
f.	Language Arts	0, 1, 0, 0, 0, 0	Mean 0.17	Mode 0

			Time Spent				
			Little			Much	
7.	How much time do students spend using globes in your class?		1	2	3	4	5
		Totals	4	1	1	0	0
			Mean 1.5			Mode 1	
8.	How often do the terms (earth, biosphere, gravity, sun, moon, day, night, rotation, etc.) appear in your instructional content (discussions, texts, etc.)?		1	2	3	4	5
		Totals	1	3	2	0	0
			Mean 2.17			Mode 2	
9.	How much time has your class spent visiting science and space museums such as the Omniplex?		1	2	3	4	5
		Totals	6	0	0	0	0
			Mean 1.00			Mode 1	
10.	How often have you talked with your class about how the earth looks at high elevations?		1	2	3	4	5
		Totals	2	3	1	0	0
			Mean 1.83			Mode 2	
11.	How frequently has your class watched television programs such as:						
	a. Nova		1	2	3	4	5
		Totals	4	1	0	0	1
			Mean 1.83			Mode 1	

	b. NASA programs		1	2	3	4	5
		Totals	3	2	1	0	0
			Mean 1.67			Mode 1	
	c. Karl Sagan programs		1	2	3	4	5
		Totals	5	0	0	1	0
			Mean 1.50			Mode 1	
	d. 321 Contact		1	2	3	4	5
		Totals	4	1	0	1	0
			Mean 1.67			Mode 1	
	e. Other educational programs (films) related to earth		1	2	3	4	5
		Totals	4	1	1	0	0
			Mean 1.50			Mode 1	
12.	How often does your class discuss these programs?		1	2	3	4	5
		Totals	3	1	1	1	0
			Mean 1.50			Mode 1-2	
13.	How frequently do students in your class play games in which they could observe the effects of gravity (e.g., basketball, jacks, etc.)?		1	2	3	4	5
		Totals	3	3	0	0	0
			Mean 2.00			Mode 1	
14.	How much time do students in your class spend reading or looking at books in which the earth's shape, gravity, or position in space are discussed or pictured?		1	2	3	4	5
		Totals	1	4	0	1	0
			Mean 2.17			Mode 2	
15.	How often do you discuss with your students the cause of day and night or the seasons?		1	2	3	4	5
		Totals	2	2	1	1	0
			Mean 2.17			Mode 1-2	
16.	How much time have you spent discussing the effects of gravity with your class?		1	2	3	4	5
		Totals	3	2	1	0	0
			Mean 1.67			Mode 1	
17.	How frequently have you talked with your class about the earth's shape?		1	2	3	4	5
		Totals	0	4	1	1	0
			Mean 2.50			Mode 2	
18.	How often do you discuss the earth's position in space with your class?		1	2	3	4	5
		Totals	1	4	1	0	0
			Mean 2.00			Mode 2	

VITA

M. Frances Fenderson

Candidate for the Degree of

Master of Science

Thesis: INVESTIGATING ELEMENTARY CHILDREN'S UNDERSTANDING OF EARTH'S SHAPE, GRAVITY, AND POSITION IN SPACE

Major Field: Environmental Science

Biographical:

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