DOCUMENT RESUME

ED 312 047 PS 018 294

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TITLE	Cognition of Space Depicted in Graphic Representation.
PUB DATE	Apr 83
NOTE	29p.; Paper presented at the Annual Meeting of the American Educational Research Association (Montreal, Canada, April 11-17, 1983).
PUB TYPE	Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Cognitive Development; *Concept Formation; Educational Practices; Elementary School Students; Elementary Secondary Education; Guidelines; High School Students; *Imagery; *Models; Preschool Children; Preschool Education; *Space
IDENTIFIERS	*Graphic Representation; Theory Development

ABSTRACT

Discussion covers underlying assumptions of children's acquisition of a concept of space and explores educational implications of the knowledge of these assumptions for early childhood programs. Initial sections of the paper concern activity as a basis for cognition of space, graphic representation, and mental imagery. Findings of studies that led to the formulation of the Hiatt Model of Graphic Representation revealed that children's understanding of space is different from adults'; acquisition of a concept of space occurs over many years; and graphic representation of space occurs in a developmental sequence related to age. Levels of the model included sensorimotor, preschematic, schematic, prerealistic, realistic, and conceptualistic. Drawings during the sensorimotor, scribble stage suggest a movement from random scribbles to controlled scribbles, and support the idea that freedom of movement leads to self-control. At about the age of four, the child begins to differentiate objects from sensorimotor activity in its graphic representations. The emergence of the baseline and skyline at 7 years of age indicates that the older child perceives himself as part of his environment, but not the center of it. Levels of the model are described and illustrated. (RH)

Cognition of Space Depicted in Graphic Representation

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Paper presented at the symposium on Educational Implications of Children's Acquisition of Space, Annual Meeting of the American Educational Research Association, April 11-17, 1983, Montreal, Canada.

The intent of this paper is to present the underlying assumptions of a children's acquisition of a concept of space, empirical studies which generated and refined the Hiatt Model of Graphic Representation, and educational implications of such knowledge for early childhood programs.

Activity as a Basis for Cognition of Space

The infant enters the world holistically perceiving the space surrounding his body. This newborn does not yet differentiate his body from that of his surroundings. Equipped with a set of reflex actions, the youngster begins to interact with his environment and successively differentiates himself from other things. The youngster's sensory awareness coupled with motor activity serve as the basis of all subsequent acquisition of a concept of space.

Early behavior appears global in nature. The child performs the same behavior in a variety of settings. When the behavior is appropriate to the situation, the child receives pleasure and, when it is inappropriate, the child receives a sense of discomfort. For example, rolling over provides a new outlook on life and is pleasurable when accomplished in the middle of the crib or floor. Rolling over is not pleasurable when the infant hits the bars of the crib or the legs of a table resting on the floor. As pleasure or pain is attached to various sensorimotor activities within various environmental situations, the child begins to differentiate his activity and the space about him. Spatial awareness occurs as the young child connects appropriate behavior with the perceptions of his environment.

Piaget and Werner are two developmental psychologists who have devoted considerable research and writing to a child's acquisition of a concept of space (Hart and Moore, 1973; Piaget, 1969; Piaget and Inhelder, 1948; Potegal, 1982). Their work supports the notion that movement first appears as global interpretations and becomes refined through successive approximations by the individual learner. They contend that approximations may have external controls, such as the crib bar or table legs as described in the example, but the actual learning or change in reorganization of the mental schema can only occur within the individual. Individuals may choose to respond to external forces in a situation or ignore those forces. If the learner chooses to respond to such external forces, he will refine his behavior and reorganize his scheme.

Whitehead in collaboration with Russell connected work on sense perception with principles of physics by applying the logic of relations (Fitzgerald, 1979). His method showed that perception and scientific principles move from the whole to the parts and that knowledge is constructed by the individual. Points and events are discrete entities, but points can be classified into larger unities and events are overlapping in space. His system of extensive abstraction suggests that persons organize and reorganize perceptions of space from a particular point of view. Each person can organize his perception of space differently, and this organization can be continually refined into more complex parts and network of relationships.

Graphic Representation and Mental Imagery

A graphic image is a visual representation of an internal concept. Graphic representation is a fundamental characteristic of man. Human beings impose order on the myriad of visual pieces of information by representing such relationships and symbols in graphic form. Graphics observed in the French caves of Lascaux, Egyptian tombs and reliefs of Mexico attest to man's desire to record his thoughts. Graphic representation becomes the means through which a creator can tangibly reflect his thought processes.

Changes in a child's conception of space are revealed in their drawings. Drawing is the act of pictorially representing a mental image, a mental schema of self, objects, and events. A child's level of graphic representation as evidenced by drawing can serve as a form of measurement of the child's conception of space.

A distinction must be made between a mental image and a perception image as this paper focuses on the former, not the latter. A perceptional image occurs in the short term memory when the senses are collecting information (percepts) from the surrounding environment. In this process the individual attends more closely to some aspects of the environment than others and acts upon that information (Carterette & Friedman, 1978). The information attended to and acted upon is transformed and stored within the long term memory. This long term memory acts as the file of information in which the child can search for particulars in the process of graphic representation.

For example, the child walks home from kindergarten. During this walk, he perceives many visual, auditory, olfactory, kinesthetic, and tactile cues from the environment. Some of these cues he attends to and others are disregarded. Aspects of the relationships among landmarks and details of those landmarks serve as the basis of his mental image of the route home. If the child were asked to draw the route between school and home, these transformed relationships and details would be recalled from his long term memory. The quality of his drawing is dependent both on the content which was assimilated from the environment through the senses and the changes of the content during accommodation (Piaget, 1969).

Evidence from children's drawings suggest that these drawings can be classified into a hierarchical order depending on the level of representation of space (Hess-Behrens, 1974; Hiatt & Raines, 1979 & 1980). The child's conception of space as depicted in drawings moves from action in space to imitation of perceptions of space to conception about relationships among objects and events. Such changes occur as functions of increasing distancing, differentiation, and reintegration between the environment and the individual. Franck has advocated in his book The Zen of Seeing that he has not fully perceived until he has sketched what he is observing. The act of drawing is one type of thinking.

Genesis of the Hiatt Model of Graphic Representation

Initial interest in creating a model of children's drawings was generated by teachers of hearing-impaired children and teachers of young normal-hearing children. These teachers were interested in developing an alternative means to assess intellectual growth. The Riles Early Childhood Education Act of 1972 in California encouraged teachers to create learning continua, a means to assess individual progress of pupil learning. In the process of attempting to create a continuum of artistic development, these teachers sought assistance at a local school of education.

The rudimentary beginnings of the Hiatt Model rest on a pilot study completed in 1978. For this study, a theoretical model of increasingly complex levels of visual representation was created. This model drew most heavily upon the work of Viktor Lowenfeld (1975), R. Arnheim (1969), and Piaget (1948). The study was conducted in a suburban school, attended by both normal and hearing-impaired children. One class at each grade level was included in the study and two classes of an adjacent child care center and two classes of hearing-impaired children. A learning center was established in each classroom and the children self-selected the activity. The teacher collected three drawings per child over the period of two weeks. Extra drawings per child were not collected.

The drawings were independently analyzed by each teacher and the researcher according to the rudimentary model. During the process of this analysis, the teachers and researcher separated drawings into two group --egocentric and decentric.

Examination of these drawings showed that most of the egocentric group could be classified into two groups--those depicting scribbling and those depicting discrete objects on a page. Other elements of the drawings were not as relevant for the purpose of separating drawings into classifications based upon increasing differentiation of schema. See figues 1 and 2 for examples of these two types of drawings.

The major factor which separated drawings into the stage of decentering was the utilization of a baseline. This new insight marks a major development in a child's organization of the world. The child has left the egocentricity of the object and has become concerned with relationships among things. Drawings depict space moving along a dimension; objects are connected to an invisible line. Piaget noted that houses are drawn perpendicular to the hill not to the force of gravity. Our study showed that chimneys are sketched sticking out of the roof as indicated in figure 3. Near the same time as the baseline, the skyline appears and objects above are connected to that. All relationships are conceived as serial and additional baselines are created if the child wishes to depict another set of relationships.

Further major categorizations based on differentiation of space were noted. Drawings of older elementary school children portrayed a coordination of two-dimensions of space. The ground of the baseline is connected to the skyline to express distance, first using overlapping planes as in figure 4. Figures assumed differing places on the ground and the person is attempting to express proportion and distance. The drawings take on a sense of realism.

In this pilot study, only one child showed the level of abstraction of space which creates for the viewer an illusion of reality. This level of abstraction requires that the person conceives of visual relationships in positive and negative terms, as depicted in shadows, and distance through the technical application of perspective. See figure 5.

Table 1 shows the results of the hearing children in this pilot study of 192 children. By the age of four, 71% of the children created objects in their drawings, drawing at the preschematic level; 22% of the children continued to represent space through the sensorimotor activity of scribbling; and 7% of the children had differentiated space to the extent that objects were attached to a baseline. At age six, 88% of the children were graphically representing space at the schematic level. Though children at later ages began to connect ground with horizon and position objects on that ground; by the age of 10-11, only 43% of the children in this study had reached that level of graphic representation.

The rudimentary model was refined into the levels of graphic representation described on Table 2. A large scale study to validate the model was undertaken. In phase 1 of this study, 1,379 drawings were collected from 252 normal and 252 hearing-impaired children, aged three to fourteen. Children in both subsamples possessed no other identifiable problem than hearing-impairment. Children who were hearing-impaired were identified in the metropolitan areas of Los Angeles and Chicago. A sample of normal children was drawn to match the age and demographic area of the hearing-impaired group.

Each child in this study was asked to draw a picture of "You and your home." This request was felt to be simple enough for the youngest child in the study and to challenge the employment of advanced techniques of perspective and shadow in the older children. The findings shown on Table 3 indicate that the normal hearing children in this study showed a similar pattern of age of emergence of a higher order of graphic representation as those in the pilot study. 75% of the children's drawings at age four evidenced differentiation of space into discrete objects; 67% of the six year olds but 88% of the seven year olds created a baseline in their drawings. Though increasing numbers of older children connect the ground to the horizon, the percentage of children ages ten through thirteen remains approximately the same, 50%. Very few children move into the level of graphic representation in which abstraction of spatial qualities are evidenced.

A second phase of this study was undertaken to gather data regarding the quality of education of the hearing-impaired and its relation to level of graphic representation and knowledge of mental operations using traditional Piagetian protocol. For the purposes of this paper, the findings of importance are that the 106 children demonstrated similar development of graphic representation as shown in Table 4.

Analyses of drawings by boys and girls indicated that there is no difference in the age attainment of level of graphic representation by sex (r=.09). Table 5 analyzes the data gathered in phase 2 of the study to show mean age of both boys and girls in the study and mean level of graphic representation. The coefficient of correlation between the level of graphic representation by age and ethnicity was .10 suggesting that there was little relation between ethnicity and abilty to differentiate space in drawings. Table 6 depicts the ethnic composition of the sample population in phase two of the study.

A factor analysis of hearing children's drawings pointed out that the most significant factor relating to level of graphic representation was age (r=.54). This analysis supported the contention that sex differences were not a factor, ethnicity was an insignificant factor, hearing-impairment was a factor, but that age was the most predominant factor relating to a child's level of graphic representation.

Educational Implications in Early Childhood Programs

Findings from these studies reveal that children's understanding about space is different from adults,acquisition of a concept of space occurs over many years (Liben,et al, 1979), and graphic representation of space occurs in a developmental sequence related to age. Teachers and parents of young children should provide for a variety of sensorimotor activities which will serve as the basis for progressive understanding of that concept. These adults need to be aware that spatial differentiation occurs through a child's active participation with his surroundings. The child should make the choices of movement within the confines of his world. The toddler should be provided a safe, structured environment in which he can perform and achieve a sense of control over his surroundings. Such autonomy of action fosters more opportunities for spatial differentiation. Drawings during the sensorimotor, scribble stage suggest a movement from random scribbles to controlled scribbles, supporting the idea that freedom of movement leads to self-control.

Implications for drawing at this age are that adults should foster graphic representation activities. Large sheets of newsprint on a wall, table or easel can serve as places at which drawing can occur safely. Autonomy of movement is not encouraged if the child gets reprimanded for drawing in a location not desired by an adult. Drawing implements should be kept in a secure place and used under adult supervision so that verbal reprimands are not connected to the act of drawing. Observations of young children scribbling suggest that such reflective action is highly rewarding to the children.

These studies reveal that about the age of four the child differentiates objects from sensorimotor activity in his graphic representations. His drawings reflect the images of the world about him in a form recognizable to adults. The child's egocentricity is portrayed in his drawings through exaggeration of parts, juxtaposition of parts, and discreteness of objects. Affective and cognitive aspects of space are tied together through the child's use of proportion, enclosure and proximity. Parts of objects which assume importance to the child are created very large, objects of significance are centered on the page, and objects of importance to the self are drawn near the self image on the page.

Teacher and parents should continue to encourage sensori-motor awareness, now focusing on activities which foster perception among parts of objects and between objects. Games as Simon Says, "Hide the Thimble," imitative play as dress-up and doll house, and careful exploration of objects within the immediate environment foster such spatial knowledge. Papert and colleagues at MIT developed LOGO, a computer language for children (Papert, 1980). In the LOGO environment, the child is in control of a triangle called a "turtle." Using the turtle and a set of commands, the child tells the turtle what to do. In the process of computerized graphic representation the child draws lines, arcs, and angles, creating patterns and objects. The intent of the creators of LOGO was to encourage children to self-direct exploration and form concepts underlying non-Cartesian geometry, a geometry not using a system of coordinates.

Howard Gardner, who has been directing Project Zero at Harvard, concurs with Hiatt that during these early years graphic representation appears to occur naturally (Gardner, 1979). The role of teachers and parents is to serve as support persons providing materials and encouragement.

The emergence of the baseline and subsequently the skyline at age seven indicates that the older child perceives himself as part of his environment, not the center of it. A study by Wall across forty-one countries showed that by age eight 96%

of the children portrayed a baseline in their drawings (Lowenfeld, 1975). The creation of the baseline shows a major differentiation of space. Objects instead of being discrete entities are now related along an axis. The child grasps space as connecting things.

This connectedness of things indicates that the child is ready to explore the environment beyond his immediate surroundings. Proximity of objects along the axis of exploration is one aspect of spatial relationships. Mapping landmarks and routes is one means to encourage active thinking of those relationships. Field trips to a variety of places expand knowledge of space. Walking provides the richest exploration of space since the child is in control. The guide can foster thinking through questioning, questions relating to next to, between, above, below.

Following such exploration, the child should be encouraged to recreate his experiences. Such recreation can include constructing model environments in the sandbox or with blocks, building places with Lego and other similar toys, and drawing. Measuring is another means to stimulate spatial relationships. Metric measurement promotes thinking about size, distance, and volume. The adult during these years should serve as a guide, encouraging active perception and classification of perceptions.

A major report by the American Council for the Arts in Education was entitled Coming to Our Senses. The thrust of the report was a call for educators to realize that contemporary classrooms are sterile (American Council, 1977). This is not a new call. Dewey eloquently argued for educational experiences which would make new demands on the child's existing powers of observation and stimulate keen awareness of all his life (Archambault, 1974). The report reminds the reader that only through the arts can man perceive his environment more clearly and become attuned to his surroundings.

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Table 1

Pilot Study: Number of Children By Age at Each Level of Graphic Representation

Level of Graphic Representation	Number	Age 4	5	6	7	8	9	10-11
Sensorimotor	9	9						
Preschematic	44	29[a]	11	3	1			
Schematic	88	3	12	23[b]	7	7	17	19
Prerealism	36				4	10	7	15
Realism	1							1

[a] $p < .01$, ignoring empty cells

[b] $p < .05$, ignoring empty cells

Table 2

Hiatt's Development Levels of Graphic Representation*

Level I - Sensorimotor

This first stage, whose name is derived from Piagetian research, begins when the child intentionally uses a drawing tool to create a visual mark. Drawings at this stage contain a variety of scribbles from rudimentary lines and dots to circles and spirals. The drawings portray the sensorimotor images of the child.

Level II - Preschematic

The child's drawings depict a symbolic visual representation of an object. During this stage, the drawings are given a name. At first, the child names the drawing after the act of graphic creation, but slowly the child moves toward naming the drawing during the activity and finally to naming the drawing at the onset of the activity. This is similar to the manner in which children learn to speak. First gestures precede the words until the words precede the gestures. Drawings by children at this age evidence the child's egocentricism as the child juxtaposes objects, centrates and distorts details, and chooses color based on emotion, not reality. Objects at this stage are not interconnected but exist as discrete images.

Level III - Schematic

This stage evidences a linear spatial relationship between objects. A baseline and a skyline appear, and all objects are attached in serial fashion to one or the other. If a slope is drawn, the child draws the objects perpendicular to the slope rather than to the visual field. No mental image of the relationship between coordinates appears to exist. At this stage, the child's schema of objects can be readily identified by parents and teachers. During this stage the child concentrates on adding significant details and correct color to his schema.

Level IV - Pre-realism

The child graphically connects the horizontal and vertical coordinates, and space is conceived as two-directional. The skyline and baseline connect to form the horizon. During this stage, the child works on placing objects correctly one behind the other to show distance and on creating objects in correct proportion to each other. Objects may appear as if to be moving off the page since the child now grasps that his drawing is capturing only one part of his environment.

Level IV - Realism

Mental images are drawn, applying abstract rules such as the rules of projective geometry dealing with perspective. Shading and shadows are added to create the illusion of depth and realism. Technical skills in applying relationships among line, space, light, color, and texture are acquired in order to portray objects realistically. During this stage, the student actively studies and uses increasingly complex skills to draw his internal mental images.

Level V - Conceptualism

At this stage, the artist has acquired a repertoire of technical skills so that a medium is mastered. His work now concentrates on employing those skills to express his individualistic, impressionistic meaning or interpretation of reality. The drawing extends the viewer's cognition to the artist's conception about persons, places, and events.

*Note. The five levels of graphic representation are based upon a sequential cognition of space moving from egocentric psychomotor level of scribbling to connection of scribbles to create an object to linear connection of objects or one-dimensional cognition to two-dimensional cognition in Level III to three-dimensional cognition in Level IV and four-dimensional cognition in Level V. See Appendix A for sample drawings.

Table 3

Phase 1: Number of Hearing Children by Age

at Each Level of Graphic Representation

Level of graphic representation	Total n	Number of Hearing Children by Age										
		3	4	5	6	7	8	9	10	11	12	13
Sensorimotor	9	7	2	0[a]	0							
Preschematic	36		10[c]	13	8	3	1	1				
Schematic	134		0	9	16[b]	23[c]	25	16	13	13	14	5
Pre-realism	70					0	6	9	13[b]	18	18	6
Realism	3									0	2	1
Total number of children	252	7	12	22	24	26	32	26	26	31	34	12

[a] 0's are placed in cells in which a frequency count might occur.

[b] 50% or more of children's drawings evidence next level of graphic representation.

[c] 75% or more of children's drawings evidence next level of graphic representation.

Table 4

Pnase 2: Number of Hearing Children by Age

at Each Level of Graphic Representation

Level of graphic representation	Total n	Number of Hearing Children by Age						
		5	6	7	8	9	10	11
Sensorimotor	0	0[a]	0					
Preschematic	14	5	5	3	0	1		
Schematic	74	6[b]	16[c]	11	11	11	14	5
Pre-realism	18			1	2	3	2	10[b]
Realism	0							0
Total number of children	106	11	21	15	13	15	16	15

[a]0's are placed in cells in which a frequency count might occur.

[b]50% or more of children's drawings evidence next level of graphic representation.

[c]75% or more of children's drawings evidence next level of graphic representation.

Table 5

Phase 2: Mean Age and Level of Graphic Representation (LGR) of Boys and Girls, Ages 5-11

Mean age in years		Mean LGR		Range of LGR
Boys	Girls	Boys	Girls	
5.7	5.7	2.5	2.6	2 - 3
6.6	6.6	2.6	2.9	2 - 3
7.5	7.5	2.8	3.0	2 - 3
8.4	8.3	3.2	3.1	3 - 4
9.7	7.5	2.9	3.4	2 - 4
10.5	10.4	3.2	3.3	3 - 4
11.3	11.5	3.9	3.5	3 - 4

Note. LGR 2 is preschematic: representation of discrete objects
LGR 3 is schematic: representation of objects on an axis
LGR 4 is prerealism: representation of three-dimensional space

Table 6

Ethnic Composition of Sample Population in Phase 2

		Ethnic Group			
		Caucasian	Hispanic	Black	Asian
Number of children	Hearing-impaired	83	20	3	1
	Hearing	74	19	6	7
Percent of total sample population		73.7%	18.3%	4.2%	3.8%

Appendix A

Sample Drawings

Figure 1. Child's drawing at sensorimotor level of graphic representation.

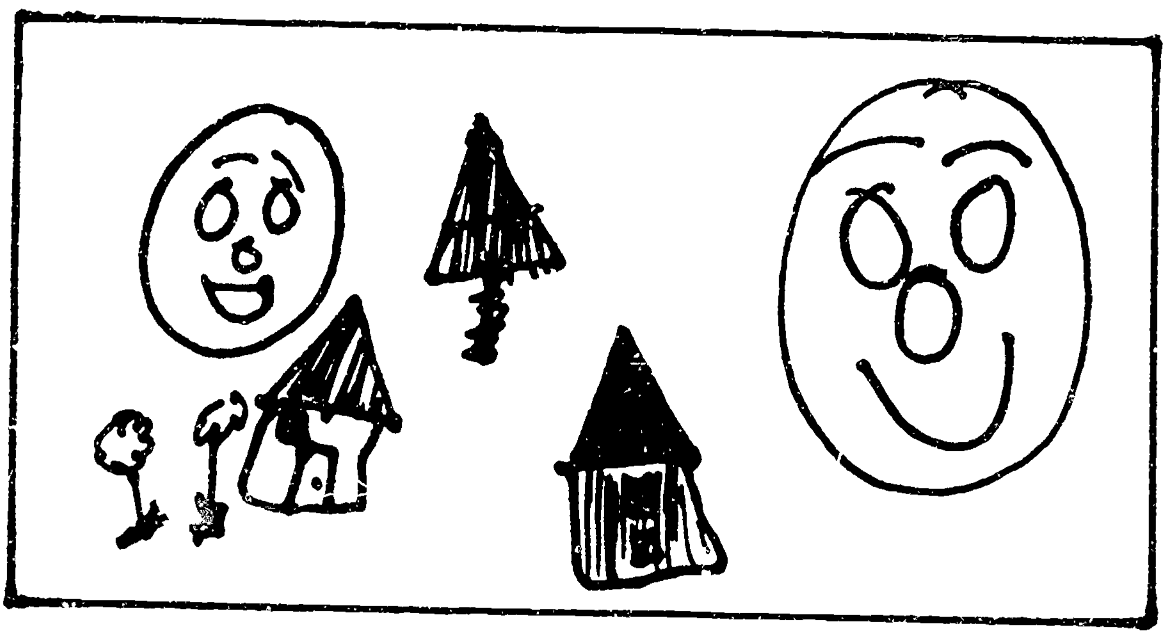

Figure 2. Child's drawing at preschematic level of graphic representation.

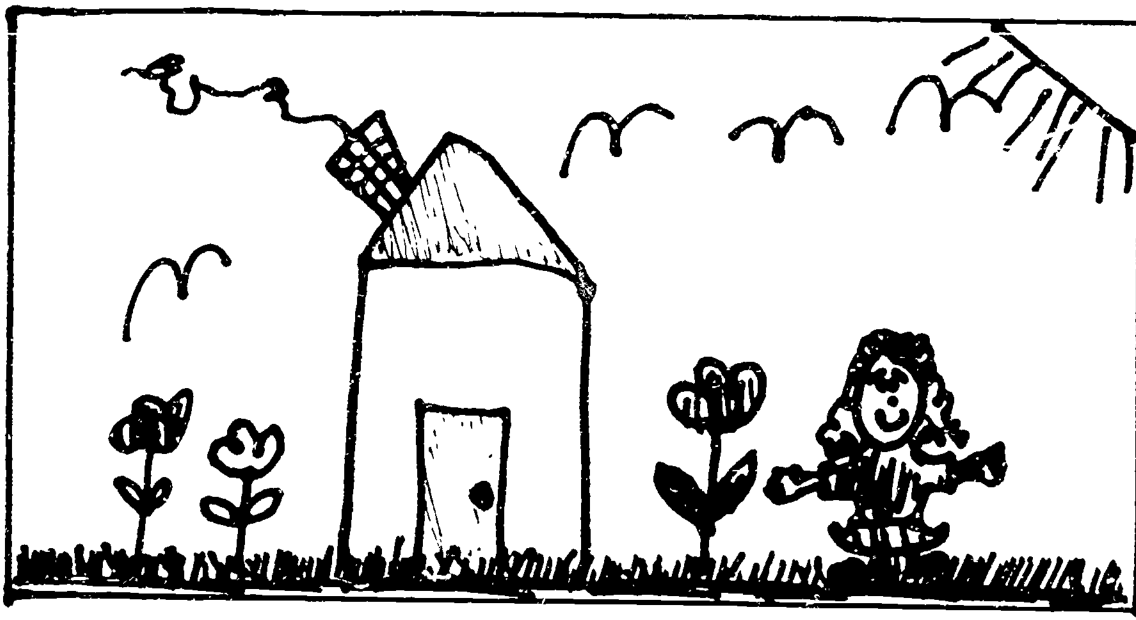

Figure 3. Child's drawing at schematic level of graphic representation. Note angle of the chimney.

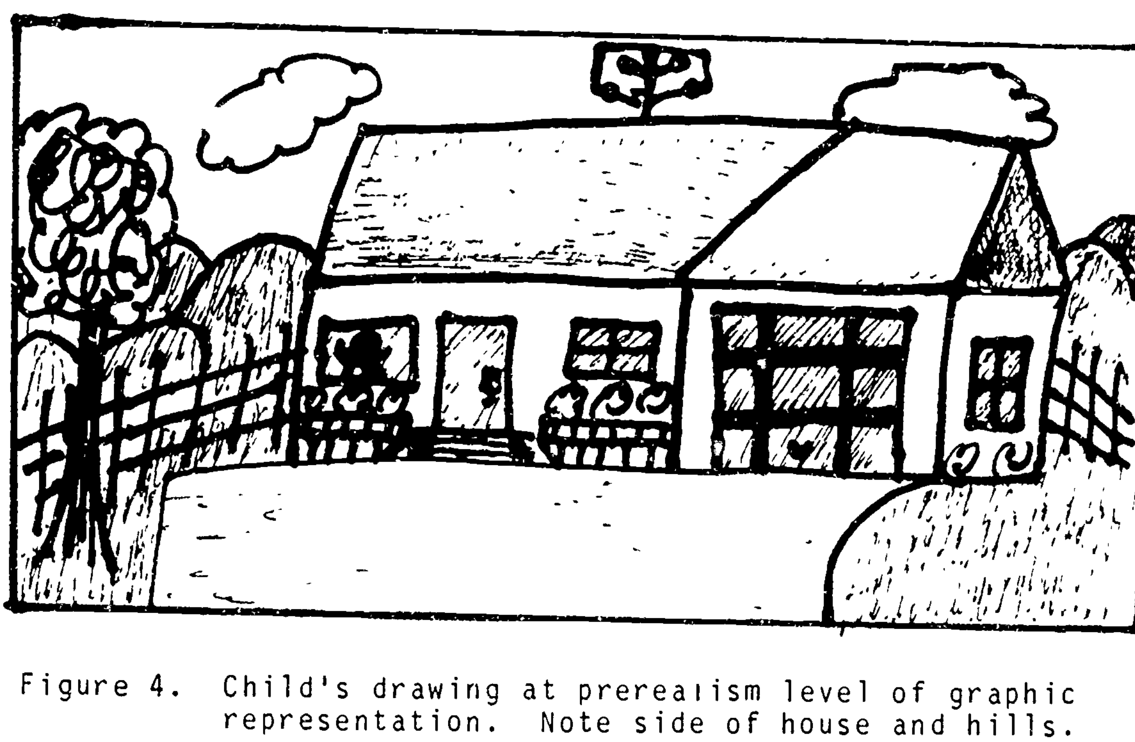

Figure 4. Child's drawing at prerealism level of graphic representation. Note side of house and hills.

Figure 5. Adolescent's drawing at realism level of graphic representation.

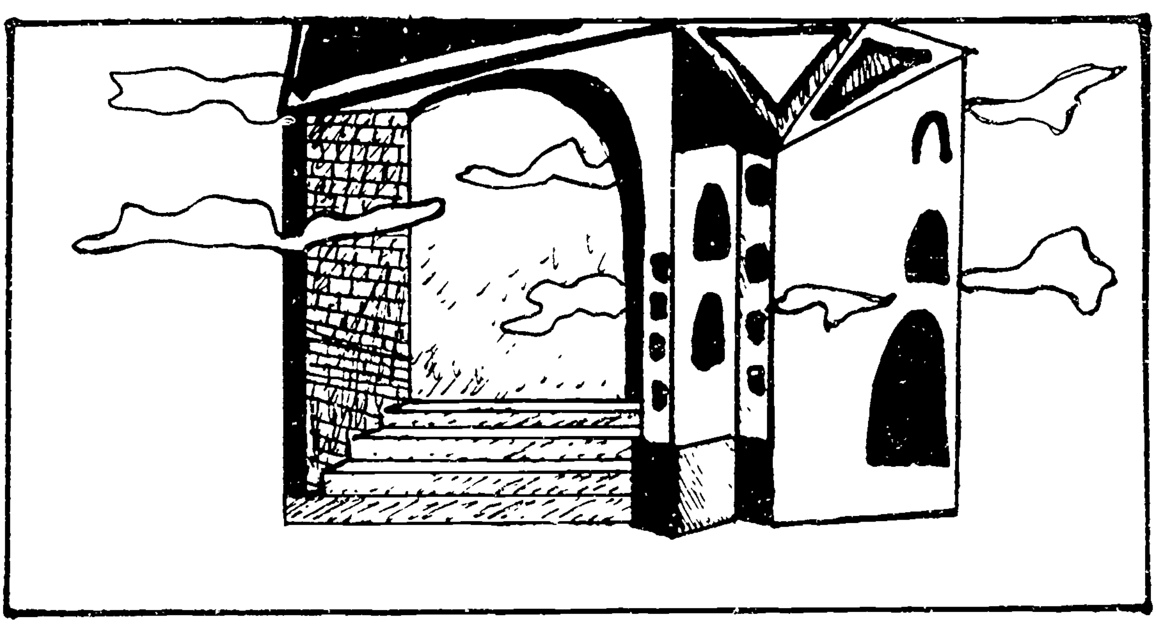

Figure 6. Young adult's drawing at conceptualism level of graphic representation.