

1977

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Recommended Citation

Allen, Thomas E. (1977) "Implications of Piaget for the Everyday Laboratory Experiences of Children," *Iowa Science Teachers Journal*: Vol. 14 : No. 2 , Article 28.

Available at: <https://scholarworks.uni.edu/istj/vol14/iss2/28>

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IMPLICATIONS OF PIAGET FOR THE EVERYDAY LABORATORY EXPERIENCES OF CHILDREN

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Introduction

In recent years, we have seen a great increase of interest in the work of Jean Piaget. Educational psychology courses and magazines for teachers feature frequent discussions about the Swiss psychologist and his research. Such discussions, however, often dwell on his descriptions of the stages of intellectual development and the cognitive abilities characteristic of each stage. Such an emphasis on classification is unfortunate because it encourages categorization of children while diverting our attention from the more important aspects of Piaget's discoveries -- Piaget has analyzed the learning difficulties of many children and how children learn and, by implication, has shown how one might teach to overcome these difficulties.

Piaget's Findings

Piaget's findings, if taken seriously and implemented logically, seem to demand a more or less radical departure from the typical present day laboratory experience. Four features of the learning process demonstrated by Piaget seem to hold special implications for us as science educators. The first of these -- "Children (with concrete thinking patterns) need objects in order to think logically" -- is the least radical of the four. At least in theory, the majority of teachers of science agree with this finding and its general acceptance is mirrored in many science curriculum programs which utilize manipulative objects for instruction. In practice, however, we still witness a great number of teachers trying to teach scientific concepts through verbal experiences (lectures, discussions, readings, etc.) instead of concrete experiences with things. Nonetheless, most science educators accept the Piagetian conclusions -- "Logical thinking did not derive from verbal learning but, rather, from a total coordination of actions on objects." AND "Learning resulted from what one *did to* objects in his environment and the doing had to be both physical and mental." (Piaget, 1964).

The other three features which Piaget and others have shown to be related to facilitating learning demand a more basic change in our approach to teaching science. Each condition of the learner identified by Piaget seems to imply the same decision on the part of the teacher -- create a science laboratory and classroom that is a very flexible, spontaneous and open. Behavioral objectives, contrived experiments, guided "inquiry discussions,"

and sequenced experiences leading to discovery are too artificial and out of step with children's learning patterns to help them learn. Examine these Piagetian findings and think about their implications. Decide for yourself if an open laboratory environment is not needed to help students learn best .

Finding 1: Piaget has shown that children of the same chronological age will differ one from another in their level of cognitive development. Each child is at his/her own unique level and may perform at differing cognitive stages when attempting different tasks.

Finding 2: Formal instruction has little or no benefit toward helping a child understand an experience. Finding 1 is much easier for us as teachers to accept than this statement. With only a small amount of reflection, we can observe that each student really does vary from every other in how he/she views problems, sets up schemes to solve them and decides what "proof" represents a solution for the problem. It is much more difficult to accept the fact that, if a student does not immediately sense the logic of an explanation, review and repetitious rewordings of the explanation do not beget understanding. We want to believe that as teachers we can explain and children can learn.

Directly showing a child how something works rarely has any real effect on learning. Even the directed inquiry approach by which a child is guided through questions to uncover answers does not demonstrate the logic of a solution to a child. Piaget holds such programming leads to a kind of verbalization of images that only fosters mental associations not understanding. The learning behavior is only temporary. Piaget (1964), Smedslund (1961), Leibherr, *et al.* (1975), along with others have noted this principle. Such learning does not allow the child to truly invent the knowledge and Piaget holds that "to understand is to invent." (Piaget, 1974).

Finding 3: Children need to perform some tasks over and over. Yet, on other tasks, children may need a single exposure to the experience to satisfy their intellectual needs. On any given task it is very difficult, if not impossible, to predict which child will feel a need to repeat the task and which person will need to move on. This varying need for repetitious activity is easily observed. Watch children play with water or blocks. Some children will do the same task over and over (*e.g.*, Fill up a spoon with water and carry it to a bucket or stack up and knock over a tower of blocks). Other children will do many different activities with the same materials in the same amount of time.

Implications

What are the implications of these findings? A science educator who attempts to give children meaningful and intelligible experiences must be aware of the extreme difficulty of the teacher's situation. The vacillating

nature of the child's learning needs creates such an unmanageable variable that creating a meaningful learning environment may seem uncontrollable. The teacher cannot possibly know on any given day at what cognitive level a child will be able and willing to work. The teacher cannot know how fast the student will be able to move from one task to another. Planning for a set outcome or a sequence of experiences denies the variability of cognition in the classroom. Exact planning for exact outcomes is unrealistic and without an adequate psychological base.

This does not mean the situation is uncontrollable. The fact that the teacher doesn't know each child's cognitive needs at every moment is not ignorance. In this case, to know that you don't know everything about every child is to know quite a bit about each child. The teacher is working in an environment of informational scarcity, but this can be controlled by choosing a teaching strategy that circumvents this knowledge problem. The open classroom strategy best seems to cope with this insufficiency of knowledge -- an insufficiency each science teacher must face if Piaget's research is taken seriously.

In an open environment, the learning conditions seem more compatible with Piaget's finding. The students are given manipulative objects and allowed to manipulate and experiment with them as they see fit. Each student can find his own level. In classrooms in which the teacher directs the students to a specific objective, the situation demands that each student be flexible enough to interact at the teacher's level. Piaget's work demonstrates that only a few students will be able to understand an adult's logic. However, in a student-directed classroom, the only formal thinker, the only highly educated person -- the teacher -- is asked to be flexible enough to interact with each student at his level. This seems a more natural and promising situation.

In addition, the open classroom breaks the ignorance barrier. No longer does the teacher need to be able to predict each student's cognitive ability. In the student self-directed science laboratory, students can be given objects which have several intellectual entry points. The Cuisenaire rods are good examples of such science materials. A child who is pre-operational can build "pretend" houses, people, airplanes, etc. from a few pieces. A child at concrete operations can play with and manipulate the rods while gradually uncovering the patterns and relationships present in the rods. A formal thinker can hypothesize patterns and test them. By watching the student and his/her interaction with the objects, the teacher can infer the level at which to interact with and help the child discover. What the teacher cannot do (always choose an activity on the appropriate cognitive level), the child does naturally. As Matthews *et al.* (1971) noted, "when the child is given his freedom to investigate a particular part of his environment he must by necessity investigate it from the particular level that makes sense to him, he cannot interact with phenomenon at some meaningless level unless you, the

teacher, dictate a starting point." We must allow our students to begin at their beginnings, not our beginnings. They must formulate their explanations, not ours. This can only be done by allowing each student to work with objects at whatever cognitive level makes sense to each person.

The problem of profitable repetition also disappears in the open classroom. The child is allowed to repeat an activity as long as the student perceives a need. There is no need for teacher decision because the child is allowed to be driven by his own perceived needs.

Finally, the inability to instruct is a problem which remains in either a teacher-directed or student-directed strategy. In the student-directed, however, the chances of intellectual growth are greatly enhanced. When a teacher moves among the students and asks each child what he is doing, why and what he will do next to test his explanation, the student must reconsider and self-evaluate his/her knowledge. The student may wish to test his/her ideas and determine how generalizable is the explanation. He/she may find a result that is discrepant or may even find the explanations are sufficient to clarify new situations. In any case, the intellect must cope with new knowledge. Jean Piaget credits such self-regulatory mental activity as a most powerful factor in the growth of intelligence. By helping students confront the logic of their own explanations, we can encourage the growth of logic. We cannot teach logic. We can only help students grow in logic by providing opportunities for each student to make up knowledge and evaluate its usefulness for answering personally formulated questions about the world.

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Thomas Edison

Thomas Edison successfully produced rubber from goldenrod. However, it was both inferior and more expensive than that which was made from the tropical rubber plant.