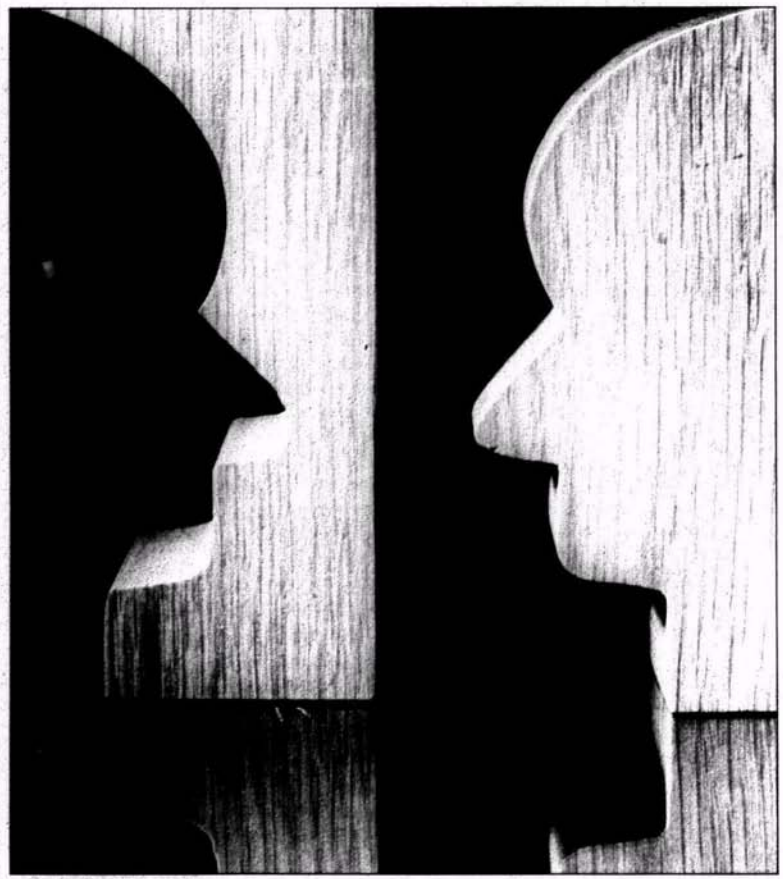
Cognitive Levels Matching

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". . . if the aim of intellectual training is to form the intelligence rather than to stock the memory, and to produce intellectual explorers rather than mere erudition, then traditional education is manifestly guilty of a grave deficiency."
—Jean Piaget



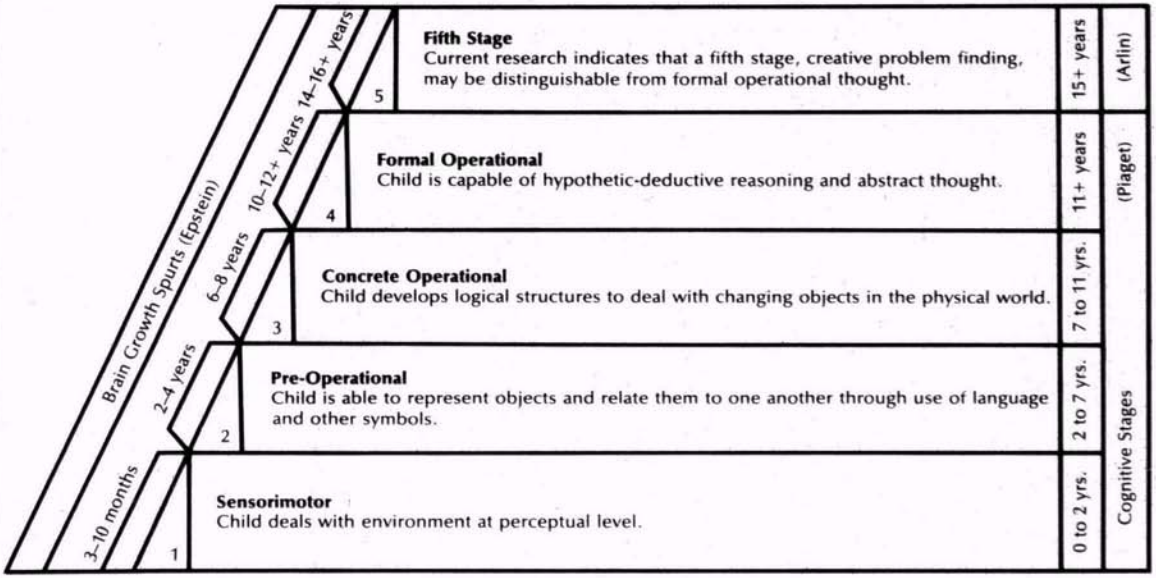
The Cognitive Levels Matching Project is designed to help teachers assess the cognitive developmental levels of students and to analyze curricula in terms of students' cognitive demands. Initially inspired by the work of the biophysicist Epstein (1974, 1978, 1979a, 1980), the project also reflects the theory and observations of Inhelder and Piaget (1958, 1964), and relies heavily on the work of several cognitive developmentalists (Arlin, 1977, 1981; Elkind, 1976; Hunt, 1961; Sigel, 1969, 1978; Sigel and Sanders, 1979).

Epstein's research indicates that human brain growth occurs in spurts rather than in simple linear increments across time. His work supplies one possible source of neurobiological support

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Figure 1. Parallel Between Epstein's Brain Growth Spurts and Piaget's Stages of Cognitive Development.



for the Piagetian model of cognitive development. The development of logical thinking in that model is characterized as occurring in four distinct stages during particular chronological periods from infancy through adolescence (Piaget and Inhelder, 1969). Each stage—sensorimotor, pre-operational, concrete operational, formal operational—represents a new way in which the child/adolescent actively constructs knowledge of the world. Epstein's findings regarding the chronology of brain growth spurt periods is congruent with Piaget's timing of the onset of each of the cognitive developmental stages. Epstein identified a fifth stage of brain growth, however, for which there was no counterpart in the original Piagetian model. Recently, such a stage has been proposed within the Piagetian and dialectical frameworks (Arlin, 1975; Riegel, 1973). Figure 1 illustrates the parallel between Epstein's brain growth periods and the Piagetian stages in the development of logical thinking, including the fifth stage.

There is some divergence between the Epstein and Piagetian models. Significantly, Epstein reports that about 34 percent of all adolescents use formal operational thought. Other researchers suggest the range to be between 20 percent and 75 percent (Martorano, 1977; Neimark, 1975; Schwebel, 1972). Figure 2 summarizes the percentages of children who attain specific cognitive levels by particular ages as reported by Epstein (1979b).

This figure is in sharp contrast to Inhelder and Piaget's assertion (1958) that nearly *all* adolescents possess the mental structures to engage in formal reasoning. It is this discrepancy between potential for and realization of formal operational thought that led to the central hypothesis of our project, namely that the proposed changes in the growth of the brain may structurally set up the neurobiological possibility for the occurrence of a change in cognitive functioning and that, particularly in the case of formal reasoning, such changes can best occur in the face of appropriate instructional intervention and/or experience.

Figure 2. Percentages of Children Who Reach Cognitive Levels of Development by Age.*

Age (Yrs.)	Pre-Operational	Concrete Onset	Concrete Mature	Formal Onset	Formal Mature
5	85	15			
6	60	35	5		
7	35	55	10		
8	25	55	20		
9	15	55	30		
10	12	52	35	1	
11	6	49	40	5	
12	5	32	51	12	
13	2	34	44	14	6
14	1	32	43	15	9
15	1	14	53	19	13
16	1	15	54	17	13
17	3	19	47	19	12
18	1	15	50	15	19

*It must be noted that "pre-operational" here refers to performance with respect to formal operational tasks. From age eight upwards, most children will successfully complete concrete operational tasks. Some, however, will attempt to solve formal operational tasks by trial and error; thus their performance is characterized as similar to that expected from those who are functioning at the pre-operational stage of cognitive development.

"Developing teacher sensitivity and knowledge through inservice education is the first step of our developmentally oriented intervention."

Matching Tasks With Abilities

Piaget (1979) suggests that children need to build up a repertory of experience and action upon which they can reflect and out of which they will ultimately build concepts. If this is the case—and we believe it is, particularly for the development of concepts associated with the stage of formal operations—the task of educators is to contribute to that repertory by matching the cognitive demands of tasks with the cognitive abilities of learners.

While recognizing that cognitive development is influenced significantly by factors external to formal educational settings (biological, social, cultural, and emotional, among others), the hypothesis of the CLM Project is that appropriate modification of the structure and content of educational experiences (that is, curricula, environments, activities, and interactions) to match the cognitive abilities of growing children facilitates cognitive development. Since teachers are responsible for structuring most in-school educational experiences, developing teacher sensitivity and knowledge through inservice education is the first step of our developmentally oriented intervention.

Inservice Education

A major goal of the Cognitive Levels Matching Project is to enable teachers to guide students' skill acquisition and problem-solving processes in ways consistent with the students' cognitive abilities. To do so requires: (a) an understanding of the process of cognitive development, (b) a method of assessing the cognitive abilities of students, and (c) taxonomic models for analyzing and restructuring educational experiences and curriculum.

Understanding Cognitive Development. To develop a thorough understanding of the process of cognitive development, the inservice education provides teachers with the opportunity and means to analyze and assess many facets of their work. By the conclusion of the course, teachers are expected to:

1. Identify the characteristics of each of the four stages associated with Piaget's model of cognitive development
2. Relate the brain growth periods of Epstein to specific cognitive stages and levels
3. Critique Piaget's stage model with respect to general educational implications
4. Analyze students' work for information relevant to cognitive levels
5. Examine their own teaching and questioning styles in terms of assumed and implied cognitive demands
6. Generate examples of the specific cognitive schemes identified in the Piagetian model through their own teaching and content areas

Assessing Cognitive Levels. Assessing the cognitive levels of students involves both an analytic understanding of students' questions and responses in daily interactions in the classroom, as well as use of more formal techniques. The teachers' daily analyses are an informal means of determining cognitive levels. The use of the clinical method with the traditional Piagetian tasks and of a newly developed Arlin Test of Formal Reasoning[1] are the formal means. Teachers' informal observations of students enable them to develop preliminary hypotheses about their cognitive abilities. The formal assessments are used to supplement and support teacher observations.

Through both the informal and formal assessments, the teachers begin to develop a notion of the "child's point of view," which is a fundamental understanding within the Piagetian framework (Elkind, 1976). The Arlin Test of Formal Reasoning is used to determine whether a student is primarily concrete or formal operational with respect to the eight formal operational schemes of Inhelder and Piaget (1958). The readability levels of the text restrict its use to grade six and above. Younger students are assessed individually using the classical concrete operational tasks of Inhelder and Piaget. Teachers are trained in both the clinical method and in the administration and interpretation of the group test.

Applying Cognitive Levels Matching. Emphasis in the course is placed on putting theory into practice. CLM requires teachers to match the cognitive demands of educational experiences to the cognitive abilities of their students. In order to do this, teachers are initially asked to analyze a curricular unit for its cognitive demands; to question whether these demands are consistent with the cognitive levels of the students; and then to design appropriate teaching strategies, questions, and materials that adapt the tasks to the cognitive needs of the pupils if adaptation is required. A number of taxonomies and sets of strategies (Biggs and Collis, 1980; Bloom and others, 1956; Case, 1980; Shayer and Adey, 1981) have been applied or adapted to the restructuring of educational experiences.

Two brief examples of this adaptation and restructuring are presented below.

Example: Literature

The first example of CLM deals with the questioning process involved in discussing a piece of literature. This questioning process helps the teacher to informally determine the cognitive abilities of the students. The following selected line, "Roads at night seem always newly made,"[2] requires the comprehension of metaphoric language. Metaphor comprehension involves utilizing schemes and operations that are generally considered to be late concrete operational or formal operational, depending on the type of metaphor and level of abstraction involved (Arlin, 1983; Billow, 1975; Cometa and Esom, 1978; Malgary, 1981).



Roads at night seem always newly made.

Photo: Chris West

The following discussion was conducted with sixth, seventh, and eighth-grade middle school students in an inter-age language arts class:

TEACHER: What does this line mean: "Roads at night seem always newly made"?

STUDENT A (Grade 7): It was the wind and the rain. It just makes no footsteps.

TEACHER: Can you tell me some more about what you mean?

STUDENT A: Nope.

TEACHER (to Student B): Would you like to explain the line?

STUDENT B (Grade 7): So you don't know where you are going. If you keep on going, you get lost and don't know where you are. You might have a marker somewhere that you know of.

TEACHER: Anything else you'd like to add to that?

STUDENT B: I think that it's about getting lost.

TEACHER: Someone else? What does, "Roads at night seem always newly made" mean?

STUDENT C (Grade 6): Okay, like you are walking on a road and you can't really tell till you come to a light and then you see.

The teacher continued questioning using three other examples of metaphoric language. She also taped the students' responses for use in one of many informal analyses of cognitive abilities. Each student response was identified as indicative of concrete or formal reasoning. When the teacher's informal assessments were compared with the students' cognitive levels as determined by the more formal testing procedures, the accuracy of her assessments was reinforced in most instances. This comparison of informal and formal assessments provided the teacher with one type of feedback as to her developing ability to "see" a task from the "child's point of view" (Elkind, 1976).

The metaphoric sentence, "Roads at night seem always newly made," is not a simple metaphor. It requires, cognitively, multiple comparisons and their coordination. This requirement is a simple restatement of descriptions of proportional reasoning, which requires formal operational thinking. The formal scheme of proportional reasoning would be considered a necessary but not sufficient condition for the correct comprehension of this metaphor; mastery of vocabulary and relevant experiences would contribute to the condition of "sufficiency." The cognitive developmental perspective complements content and skill analyses, although it does not replace them. Students' "miscomprehension" is really a clear statement of their "points of view." They relate parts of the sentence to their own experiences and give a literal reinterpretation. This informal assessment aids the teacher in structuring the continued discussion of the book and in selecting appropriate literature materials for future classroom instruction.

Example: Earth Science

Our second example of CLM deals with textbooks, many of which make cognitive demands that children are unable to meet. A course in earth science is offered in New York State to pupils in eighth and ninth grade, approximately 13–14 years old. The majority of students at this age are unable to reason on the formal operational level, although much of the earth science curriculum requires formal operational thought. An earth science textbook[3] offers the following paragraphs on the future of humanity:

Throughout the ages, new forms of life have constantly evolved from existing forms of life. A great many different kinds of plants and animals have disappeared from the face of the earth after having existed for millions of years. Other kinds of plants and animals have replaced them.

Considering the amount of time that has passed since life originated on earth, it appears that "The Age of Man" has just begun. Man's brain probably surpasses the brain of any other animal in intelligence. This intelligence has enabled man to control his environment. Man even has the capacity to change his environment to suit himself.

In addition to the skill, concept, and vocabularly requirements for understanding these paragraphs, other assumed cognitive demands include classification, proportional reasoning, coordinating two or more frames of reference simultaneously, recognizing simple metaphors, and more. Most of these are formal operational demands.

Many of the concepts traditionally explored in earth science courses might be better taught in the later high school years since most eighth and ninth-graders do not possess the mental structures required for successfully understanding the material. They pass simply because they learn to compensate effectively: they memorize.

Since state departments of education are not likely to alter their course sequences in the near future, we stress modification or adaptation of material for an audience comprising a wider range of cognitive abilities. In the paragraph on earth science, for example, the concept of evolution could be discussed with emphasis on seriation, a component of concrete thought, and not the coordination of two frames of reference, a component of formal thought. This approach reinforces the necessity of seeing certain adaptations of curricular tasks as contributing to the child's "repertory of experiences and actions" (Piaget, 1979), as discussed earlier.

The CLM project emphasizes the need for multi-year, multi-level inservice education of teachers, which enables them to further develop their understanding of cognition and to refine their analytical skills. The follow-up courses enable teachers to do more reading about the cognitive sciences, apply to a greater extent their knowledge and newly formed ideas, share and grow with colleagues, and more fully develop their analytical skills. In subsequent years, teachers receive formal and informal feedback in their attempts to implement the CLM approach. These experiences contribute as well to their own "repertory of experiences and actions" and may lead, in turn, to the development of students who are "intellectual explorers," thereby reducing what Piaget refers to as the "grave deficiency" of traditional education.□

[1]P. K. Arlin, "The Arlin Test of Formal Reasoning," unpublished test under revision (Vancouver: University of British Columbia, 1982).

[2]Avi, *Night Journeys* (New York: Scholastic Book Service, 1979), p. 118.

[3]C. Constant and S. L. Geffner, *Review Text in Earth Science* (New York: Amsco School Publications, Inc., 1971), p. 226.

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