Research on the intellectual development of the child highlights the fact that each stage of development the child has a characteristic way of viewing the world and explaining it to himself. The task of teaching a subject to a child at any particular stage is one of representing the structure of that subject in terms of the child's way of viewing things. The task can be thought of as one of translation. In this way any subject can be taught effectively in some intellectually honest form to any school aged child at any stage of development. Education interventions work best if they match a person's state of readiness.

Jean Piaget was a Swiss developmental psychologist and philosopher known for his studies on how humans, and children in particular, acquire knowledge. Piaget was studying epistemology, which is the branch of philosophy concerned with how we come to know things. Piaget believed answers for the epistemological questions at his time could be answered, or better proposed, if one looked to the genetic aspect of it, hence his experimentations with children and adolescents; he proposed what he called a genetic epistemology. "What the genetic epistemology proposes is discovering the roots of the different varieties of knowledge, since its elementary forms, following to the next levels, including also the scientific knowledge." Piaget developed a comprehensive theory about the nature and development of human intelligence. Through a series of 4 stages, Piaget explains the ways in which characteristics are constructed that lead to specific types of thinking. The term readiness concerns when certain information or concepts should be taught. According to Piaget's theory children should not be taught certain concepts until they reached the appropriate stage of cognitive development.

The first and second stages do not concern the process of education because the children typically possess characteristics of pre-schoolers. Children at this stage lack the concept of reversibility. Reversibility is the idea that numbers and objects can change and then return to their original state. For instance if you take 2 equal beakers of water, then pour one into a thinner and taller beaker, the child will not be able to understand that the amount of liquid has not changed; and if asked which has more water the child will choose the taller beaker. Because of this lack of understanding the child cannot grasp the fundamental ideas that lie at the basis of mathematics and physics, that you conserve quantities in equations or mass and weight in an object even if they change.

Piaget used a number of creative and clever techniques to study the mental abilities of children. One of the famous techniques to demonstrate egocentrism involved using a three-dimensional display of a mountain scene. Often referred to as the "Three Mountain Task," children are asked to choose a picture that showed the scene they had observed. Most children are able to do this with little difficulty. Next, children are asked to select a picture showing what *someone else* would have observed when looking at the mountain from a different viewpoint. Invariably, children almost always choose the scene showing *their own* view of the mountain scene. According to Piaget, children experience this difficulty because they are unable to take on

another person's perspective. Needless to say a teacher is severely limited in transmitting certain concepts to a child at this stage, although there are techniques that can help children progress in their thinking.

A few techniques can be used to help the further the child's concept of invariance, or the idea that quantities can remain the same despite transformation. If a child is given a known quantity of beads or liquid, and is then asked to transfer the volume from one receptacle to another, one receptacle being tall and narrow, the other flat and wide; the young child believes there is more in the tall receptacle than the flat one. This false belief can be confronted concretely however by simply counting the beads, or measuring the liquid to show they amount or volume is the same. A teaching method that takes into account the natural thought processes will allow the child to discover such principles of invariance by giving him an opportunity to progress beyond his primitive mode of thinking through confrontation by concrete data.

Recent psychological research on concept formation has suggested that children do not generally form concepts by learning necessary and sufficient conditions for their application, but rather by coming to use prototypical examples as reference guides. Thus a robin (rather, of course, than a penguin) might be the child's prototype for 'bird'. The child, like the adult, might then be credited with having the concept, bird, without the child's ever being able to specify, successfully, necessary and sufficient conditions for something to count as a bird.

Another problem associated with teaching children in the first two stages is that they often focus on only one aspect of a phenomenon at a time, and this interferes with their understanding. For instance, children up to about seven estimate the speed of two automobiles by assuming that the one that gets there first is the faster, or that if one passes the other it is faster. To overcome such errors, one can, by using toy automobiles, show that two objects starting at different distances from a finish line cannot be judged by which one arrives first, or show that one car can pass another by circling it and still not finish first. Such an exercise would help the child toward attending to several features of the situation at once; this process is known as decentering.

The third stage of development, the *concrete operational stage*, occurs around the age of 7 years, and is characterized by the appropriate use of logic. During this stage, a child's thought processes become more mature and "adult like", although abstract, hypothetical thinking has not yet developed, and children can only solve problems that apply to concrete events or objects. They start solving problems in a more logical fashion, the child is now in school. Children at this stage are able to fluently perform mathematical problems in both addition and subtraction, and are able to classify objects by their number, mass, and weight. They also understand the concept of reversibility, so that when shown the 2 beakers of water test they

know the amount of liquid has not changed even though the shape has. The child is now a sociocentric (as opposed to egocentric) being who is aware that others have their own perspectives on the world and that those perspectives are different from the child's own.

During the stage of concrete operations stage the child is capable of grasping intuitively and concretely a great many of the basic ideas of mathematics, the sciences, the humanities, and the social sciences. But she can only do so in terms of concrete operations, or what is directly presented to them. Fifth- grade children can play mathematical games with rules modeled on highly advanced mathematics, though they may not be able to formally describe what they are doing. For instance fifth- graders can readily grasp the central ideas from the theory of functions (A function relates an input to an output, $f(x)$ is the classic way of writing) although if a teacher attempted to explain to them what the theory of functions was he would have drawn a blank. The child learns not to understand mathematical order but rather to apply certain devices or recipes without understanding their significance and connectedness. Basic notions in the fields of geometry, physics, and other subjects are perfectly accessible to children of seven to ten years of age, provided they are divorced from their mathematical expressions and studied though materials that the child can handle himself.

The act of learning a subject involves three separate processes. First there is the acquisition of new information- often information that runs counter to or is a replacement for what the person has previously known implicitly or explicitly; this new information may challenge beliefs. A second aspect of learning can be called transformation, the process of manipulating knowledge to make it fit new tasks. Transformation comprises the way we deal with information in order to go beyond it. A third aspect of learning is evaluation, checking whether the way we have manipulated information is adequate to the task. Often a teacher is crucial with helping this evaluation. In the learning of any subject matter, there is usually a series of episodes, each episode involving the three processes.

At its best a learning episode reflects what has gone before it and permits one to generalize beyond it. A student learning photosynthesis will be learning an episode in biology, which can be fitted into a more comprehensive learning experience such as learning about the conservation of energy generally. Teachers tailor material to the capacities and needs of students by manipulating learning episodes; they can shorten or lengthen the episode, provide external motivation such as praise or gold stars, and they can dramaticize the recognition of what the material means when fully understood. With regard to the optimum length of a learning episode, it seems fairly obvious that the longer and more packed the episode the greater the payoff must be in terms of increased power and understanding; this must be balanced with the recognition that there are severe limits to the amount of unassimilated information children can keep in mind.

There has been recent controversy over the effect of extrinsic rewards in the schooling environment. Some studies have suggested that, rather than always being positive motivators, rewards can at times undermine rather than enhance self-motivation, curiosity, interest, and persistence at learning tasks. Where grades are used as a substitute for the reward of understanding, it may well be that learning will cease as soon as grades are no longer given. Intrinsic motivation is a passion and interest in something that doesn't require reward or recognition from others. Children are naturally curious. Their curiosity drives them to figure out how the world works. Taking a pleasure in the understanding of the way things work is an intrinsic reward that is much more powerful than extrinsic one such as gold stars, grades or pizza parties.

Somewhere between the ages of eleven and fourteen the child passes into the fourth and final stage, the stage of *formal operations*. At this stage the child is able to operate on hypothetical propositions rather than being constrained to what he has experienced or what is before him. The child can now think of possible variables and even deduce potential relationships that can later be verified by experiment or observation. The child's intellectual operations are now reaching the level of the logician, the scientist, and the abstract thinker. At this point the child is capable of learning anything.

This conception, some argue, ignores or undervalues the fact that children are, for example, better able to learn a second language, or paint an aesthetically worthwhile picture, or conceive a philosophically interesting question, than those same children will likely be able to do as adults. Moreover, it restricts the range and value of relationships adults think they can have with their children.