From the Montessori Teachers Collective (MOTEACO.ORG)

The Psychology of Mathematics - Maria Montessori, Cambridge Education Society, Trinity College, 1935

The honor of your invitation to come and speak to you on mathematics derives, I believe, from my recent publication of two books the titles of which are unusual among books of the kind; that is to say, Psico-Arithmetic and Psico-Geometry.

These results from experiments made during nearly 20 years in our schools, where the child is left free in his choice of occupation; and where culture is actively acquired by the children themselves by means of apparatus scientifically prepared.

These experiments have not been limited only to the baby class, or to the junior school, but extend also to the first years of secondary education, and they are interesting on account of their great originality. In fact, progress in the study of mathematics is guided by the child's psychology instead of by pre-established programmes, and therefore they truly constitute unpublished chapters of an unsuccessful psychology.

In fact, numbers and their derivatives have become for the child scientific stimuli which provoke vital psychic activities, and have awakened a profound logic which would not have been thought possible in little children. The result has been a real enthusiasm for learning arithmetic and geometry; subjects which generally seem dry and difficult, and which have caused the study of mathematics to be regarded as a 'rock' or 'barrier' in the ordinary schools.

Yet it might have been logical to suppose that mathematics, being a pure creation of human intelligence would be for that reason interesting in a special way to the human mind in the course of its development. If we base ourselves on the psychology of the child we find the transmission of culture made unexpectedly easier. Nature has implanted in the child irresistible psychic impulses which incline him towards special actions necessary for his development.

There are throughout growth so-called 'sensitive periods' during which - and only during which - the different natural faculties of man can acquire perfection. Therefore subjects of instruction can become real helps to development at these periods. They are absorbed with extraordinary intensity.

Culture becomes identifiable with the construction of the personality itself; we might say it incarnates itself within the being and lives. It is then that the child-mind can give surprising revelations. The child becomes indefatigable in work, provided we offer the necessary means.

Mathematical material in particular, presented in the sensitive period in suitable fashion, permits the child to understand fundamental truths, and not only that, but to discover new relationships.

Yes, it has actually happened that children in their vital impulse of growth have found a way into questions which the already formed and rigid mind of the adult teacher had never been able to reach.

When the child was placed into an environment which corresponded to his mental necessities for development, he at once showed how erroneous were the paths we had followed hitherto in the older ways of transmitting culture. In the schools we obliged him to listen, whereas what he really needed was to 'act', to act with concentration, and therefore not to listen to someone speaking. We gave the children

things which were too simple for the level their intelligence had reached, and this bored instead of interesting them.

Here is one of the most important points: we have to give the children more difficult things to interest them. The level of work in ordinary schools is proportionate not to the true capacities of the child, but to defenses which his mind sets up against an erroneous method of teaching.

Once this truth had been understood, it became my aim to study ways of putting children's minds in contact with superior ideas which they had not been formerly allowed to reach; analyzing all the difficulties and presenting them separately by means of concrete apparatus. That is to say, to 'materialize the abstractions', abstractions that are not in themselves inaccessible to the child, but which need a material bridge to lead to their comprehension and penetration.

In this way children of nine have been able to take an interest in algebra and in the fourth and fifth powers of the binomial; in the extraction of cube roots going to many figures.

These materializations did not keep the child's mind away from abstractions. What they did was lead to abstraction, giving a point of departure materially clear and capable of experimental verification.

Generally children in the schools do not arrive at the true abstractions of arithmetic, but merely learn by heart abstract formulae, which they have not understood and which therefore are uninteresting. Instead the materialization makes one penetrate into the understanding of the idea and therefore it is a bridge which leads truly toward the abstract world. Hence problems and formulae which in the ordinary school are communicated to the children by the teacher's voice are here materialized in a group of objects.

Placed in contact with this material the child shows two fundamental things. One is that 'understanding' - having grasped the idea and learned it (which is the final point aimed at in the ordinary methods of instruction) - represents in the process of his growth only the first step of a prolonged and repeated activity. The child is like a sportsman who hunts for hours and hours, or an athlete, rejoicing day after day in his favorite exercise. That is to say, the child, after having understood, becomes a student of the question, and an enthusiastic worker in it.

The second thing we noticed was that the child's mentality and his capacity for understanding are, during the sensitive periods in which certain subjects can be learned, much greater than those of adults.

In fact, the material was constructed to communicate certain special basic truths.

But the child, in the prolonged use which he made with this material, discovered truths which it had never been our intention to include within it; and these truths discovered by the child contained surprises even for the teacher, who was often completely ignorant that these cases existed.

Theorems, corollaries and the questions asked by the child, were often so new that they could not be found in the text-books which are used in elementary and secondary schools. This caused our teachers to go and ask professors of mathematics to give them the explanation. "Look, sir", said one, "a child in my class has discovered that the square constructed on the diagonal of another square has an area twice the latter. He also found that the equilateral triangle which has the height of another for its side, is three-quarters of this other, and that the theorem of Pythagoras is applicable not only to squares, but to all regular polygons. Is this true?"

Hence, far from the results being due to the genius of a teacher, these results derive from the active and joyous enthusiasm of the children themselves. Children who have not yet turned ten years of age. And when we think that children so young have begun to study algebraic formulae and that they love studying the extensions of the theorem of Pythagoras, we must realize that the child's mind had been depressed instead of aided by the school.

These considerations of the psychological type are important from a general and human point of view; joy replaces fatigue and enormous progress is made in the acquisition of culture.

To achieve this, however, we have to put the personality of the child in the place of honor which it ought to have in the school - in that social environment which has been specially prepared for his aid and benefit.