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VALUES IN MATHEMATICS EDUCATION (1/2)

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> *The Brothers consider their professional work as a ministry. They are attentive to each of their students and especially to those most in need. They make themselves available to all in an attitude of brotherly companionship, helping them to discover, appreciate and assimilate both human and gospel values. The Brothers help young people to grow as persons who are called to realize more and more that they are children of God* (Rule 13).

What the Rule says of the Brothers on the subject of education can be said today of the lay colleagues who share the same spirit and mission in accord with the creative dynamic begun by St. John Baptist de La Salle. The teachers of Lasallian spirituality need to study the values of the science-technology culture which is spreading today in which mathematics plays an important role in guiding us according to God's plan for humankind.

> *With an open mind and yet in a spirit of healthy criticism the Brothers study the various religions, ideologies, and cultural traditions of the areas in which they establish themselves. They will be able in this way to absorb the positive values therein and so to make a valuable contribution to the education of the people around them* (Rule 18c).

In mathematics education, as in other areas of learning, the objectives can be divided into three areas: 1) information (concerning facts, concepts or principles), 2) procedures (problem solving skills to achieve results), 3) values (acquiring attitudes that lead to habits that conform to certain norms which are derived from both esteem and rejection).

This normal three-part division of educational objectives is based on an anthropology that recognizes three distinct faculties in a human being: intelligence, will and affectivity or sensitivity. Values presuppose a certain intellectual perception of an intuitive nature, sometimes an unconscious one that can be raised to consciousness by means of reflection. The faculty to approximate or the power to appraise has a marked emotional characteristic, whose product is called feeling perception by the German Max Scheler in his treatise on Ethics. Values exercise over the will a dynamic that attracts or repels and therefore they have an emotional capability which has a polarity that attracts or rejects.

Values education has its foundation in the philosophical notion of value. The Croatian-Chilean Dominican Raimundo Kupareo defines a value in his Esthetical Axiology as "being itself inasmuch as in virtue of its content means a perfection and it has a desirous attraction". In other words, values exist when some attribute of a thing is pleasing to people, thus satisfying a need or a human aspiration. These values are integrated into the educational process when an attitude or possibly a habit is brought about in the subject who is fostering them.

According to Max Scheler, those values of a biological or essential nature can be distinguished as fundamental for the total fulfillment of the human being, also esthetic values, intellectual or cognitive values, moral values that insure happiness by means of activity that conforms to reason and religious values which connect the ultimate purpose of humankind, which is God. In addition there are other values derived from these and which make them to be more specific such as formative, philosophical, recreational social and other values.

Mathematics can be defined as the study of diverse forms of quantities and their attributes, according to Aristotle in his Metaphysics (Book III, chapter 5 and Book XIII, chapter 3). That definition: 1) includes the material object or the content of his study, which is quantity; 2) recognizes the analogous and not the single-minded character of quantities, since it can be found in very diverse forms, such as numeration, configuration, extension (physical or logical), etc., which gives rise to various mathematical sciences (arithmetic, geometry, algebra, topology, symbolic logic, etc.); and 3) points out the formal objective or point of view of the discernible attributes in the various forms of quantity; so philosophy distinguishes with respect to the study of quantity in terms of its nature (in general, Ontology and in particular, the Philosophy of Mathematics).

In education, perceived values motivate learning. It is important to analyze them in order to facilitate the learning of Mathematics which is considered difficult and tedious for many students, often because they have not been adequately introduced to the variety of values and satisfaction that Mathematics can provide.

Planning for mathematics education tends to be limited to cognitive and operating or psycho-motor objectives. Value objectives attempt to develop the personality, beyond the area learning proposed for children and adolescents in formal instruction. As one analyzes *values*, which are linked to affectivity which is inherent in a good mathematics educational program, one discovers *attitudes* that can be proposed as objectives, some of which are very broad-based for curriculum design, others are more specific for classroom planning, with a view to enriching the teaching-learning process.

Cognitive value

The principal value that is of interest in Mathematics is the knowledge of that which is measurable, comparable and calculable. The main attitudes that we are interested in developing in pursuit of this value are:

a) *curiosity*, or the desire to question oneself/intellectual initiative: to suggest various situations with points, figures, surfaces or volumes, logical propositions in general; to research relationships and attributes beginning from a certain database; to reflect on how a variable increases and decreases; to examine how a variable depends on other quantities or if it is independent and causes others to change; to analyze what happens if a variable exceeds a certain amount or ventures into the negative domain; to research which linked quantity to a particular variable allows it to become null or infinite; to apply analysis and synthesis to new situations;

b) *creativity*: to manifest original examples of an understanding appropriate to mathematical concepts, of its symbolic and graphic representations; to move from curiosity to actual research of quantitative questions concerning the en-

vironment; to imagine how and where to find the necessary data to respond to these questions; to formulate a problem based on existing data; to look for alternate means of solutions, even though this may involve rough reckoning, called more academically "by trial and error"; to vary data at will and examine how other dependent quantities change as a result;

c) *reason or logic*: to establish a sequence that leads to a process of resolution; to determine the appropriate mode of arranging data, to sequence the logical steps for the resolution and for the presentation of the results; to justify why it is legitimate to carry out an operation in the resolution of a specific problem and not the other way around or applying a particular formula or using specific symbols for data and unknown quantities; to recognize principles (definitions, axioms and attributes expressed in theorems or corollaries) that justify the use of specific algorithms; to rationalize in discourse the basis of the formula or the operations used to resolve a given problem; to systematize the various possible cases for resolution or presentation of the results; to use deductions while studying situations which include interdependent sets of concepts;

d) *critical nature*: to select information before memorizing it; to judge whether all the necessary data are available or are missing or if there are extra data to be able to resolve a problem or if there are incompatible data in which case the problem is "beyond determination"; to evaluate if suggested quantities in a theoretical problem can be given in material reality; to imagine how the results will be verified; to analyze if a problem has more than one solution or if it is unsolvable; to judge if the percentage concept or other commonly used concept is legitimate to use in a particular case; to examine if two or more ways of expressing a result are in fact equivalent; to analyze if it is appropriate to calculate results with more than one decimal place; to describe if the conditions of a problem have been extrapolated or not (to penetrate the dominion of negative numbers or fractions without relating them to real numbers, etc.); to detect personal errors, those of companions or those of the instructor (eventually resolving these);

e) *a sense of space* or the capacity to perceive and distinguish forms, figures, surfaces and volumes (indispensable for children to be able to understand letters and for adolescents to recognize projections used in geography or molecular structures studied in chemistry): to identify distinct classes of: continuous and discreet forms, linear and right angles or polyhedrons, triangles, polygons, plane and curved surfaces, round or polyhedron bodies, mutual positions between straight and curved lines, between similar figures (whether homologous or not);

f) *the capacity to consider* or to value and compare, the sign of a certain type of intellectual maturity as one surpasses simply applying rules in searching for raw results that have been obtained: considering whether or not a result is reasonable; if it is reasonable then valuing the approximation technique used to define a quantity; evaluating if a found quantity is significant or negligible and why; estimating if a quantity is large or small in comparison with other data or results; judging if there is a relationship between determined properties of the various operations and what is observable in various affairs and other daily situations.

Formative value of personal development

The Brothers give special attention to their students who have difficulties at school, at home, or problems adjusting to society (Rule 40).

The capacity for one area of learning to help the development of the psychological personality is usually called formative value, in addition to its fostering the learning of information, skills and attitudes which are proper to it. All areas of learning are formative in one way or another especially if educators deliberately suggest pertinent objectives and use appropriate methods. Recommendation number 43 for the Ministers of Public Education of UNESCO in 1956 considered one of the objectives for the teaching of mathematics to be "the development of the intellectual ability and character formation".

The complementary attitudes of the personality that personal attention to each student fosters in mathematics education are primarily:

a) *attention and concentration*, indispensable to achieve any other objective in mathematics education,

b) *self-esteem*, as one discovers oneself to be capable, like any normal person, of understanding exact relationships, of expressing them correctly, of solving problems and of discussing methods and solutions,

c) *confidence in the resources themselves*, as one feels oneself to be capable of discovering and correcting errors in the plans, calculations and procedures whether they are those of one's companions or those of the instructor,

d) *expressiveness*: the ability to argue in a convincing manner, using appropriate abbreviated conventional or original symbols.

Recreational value

Mathematics was born out of a need for entertainment and the intellectual delight of free persons. The aspect of the mathematical thought comes into the classroom when students discover elegance by means of the brevity, simpleness, clarity and persuasive force in a demonstration, solution or mathematical construct. There are mathematical relationships whose simple mental consideration is attractive and delightful, such as the Pythagorean table of multiplication, Pascal's numeric triangle, numerical table values for the Cartesian representation of lines and cones, etc.

Attitudes that can be fostered in students so that they enjoy the recreational value of mathematics are:

a) *to admire* order, symmetry, proportion, infinite projection and other intelligible properties of numerical, algebraic, geometric or other mathematics science quantities;

b) *to enjoy in a disinterested manner* as one searches for truth in mathematics, in the harmony of the properties of certain quantities, in the elegant presentation of argument, in mental or manual verification of geometric or quantitative properties in general;

c) *to express* in a clean, ordered and clear form the mathematical concepts acquired in class or developed in personal or group work;

d) *to handle* puzzles and mathematical problems related or not related to the study materials, in the manner of authors such as Malba Tahan, Mataix, Lieber, Niklitschek, Kasner, Newman and others.

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