Montessori Maths and Cosmic Education:

Maria Montessori’s concept of mathematics as a means of connecting to the universe is completely different to skills and strategy based programmes, such as the ‘numeracy project,’ run in our state schools today. Yet the breakdown of learning areas in the New Zealand curriculum leans toward realising what Montessori mathematics is all about. It states… “Mathematics is the exploration and use of patterns and relationships in quantities, space, and time. Statistics is the exploration and use of patterns and relationships in data ”(New Zealand Curriculum (NZC), 2007).

While it has the noble goal of helping children make sense of their world, it seeks to do this through the concept of number, something that is a human construct, a type of language and this in itself limits us. Montessori does not see Maths and Statistics as two related but separate disciplines although they often involve different thinking and problem-solving strategies, different approaches, explanations and investigation. Montessori Maths is an integral part of everything. Our entire civilization and environment and even space itself are mathematical marvels we can discover.

In Montessori Maths, man-made mathematical concepts are tools used to build an understanding of the known universe and to explore the unknown. But, while Montessori is a scientifically proven approach to education and the Montessori maths progressions develop concrete concepts before moving to abstraction, it is a poor representation to confine it to this limited definition or separate the maths curriculum from other ‘curriculum’ areas. Both Montessori maths styles and the NZ Curriculum align in their undertaking that “Mathematics is the exploration and use of patterns and relationships in quantities, space, and time,” and they both claim to “equip students with effective means for investigating, interpreting, explaining, and making sense of the world in which they live,” the NZ Curriculum treats it as a necessary skill and a discipline (NZ Curriculum, 2007). Montessori continues beyond this; it surpasses the idea of a holistic or integrated curriculum, as the heart of these is still the curriculum. At the heart of Montessori Cosmic education (from the Greek word kosmos meaning order), is a deep and intrinsic connection to the very fabric of the universe\* (see non-verbal image and commentary).

The Montessori math programme and materials were developed through observation and experimentation aligned with a comprehensive understanding of human development, encompassing the Four Planes of Development (Birth to six, six to twelve, twelve to eighteen and eighteen to twenty-four years), and the sensitivities (Sensitive Periods) that are unique to each plane. Sensitive periods occur when the child is especially sensitive to learning specific skills that they are pre-programmed to develop (such as walking, talking, and reading). It is the first two planes of development that are the most important, the first being the most crucial (Montessori 1938, retrieved from nobleworldmontessori.com). From birth to six the child is a sensorial, hands-on explorer with an absorbent mind (0-3) and where the conscious mind is ‘born’ (3-6). The child is involved in constructing ‘self’ through developing practical life skills, competence, concentration, self-discipline, manipulation of materials and motivation through intrinsic satisfaction. Montessori math materials give them a concrete introduction to fundamental mathematical concepts and the logical reasoning underlying them in a way that supports this self-construction (Wordpress.com).

Through engaging with the materials at the pace and stage they need, the child becomes ‘normalized,’ (a phrase used to describe a child’s natural state of being… content, focused, independent, self-motivated and concerned for others). How they do things is just as important as what they do. In this state they have the freedom to construct themselves. Montessori education provides them with three other ‘tools’ to do this - the ‘Prepared Environment,’ Didactic Materials and the support of a teacher who is trained to understand their developmental needs, facilitate not indoctrinate and ‘follow the child’ (Montessori, 1983).

The prepared environment is one that allows the child to fully access materials suited to their needs and stage in a clean, tidy, beautiful and ordered environment. Equipment and materials are purposeful, child-friendly, child-sized, orderly, complete and always in the correct place.

The Didactic materials are scientifically developed and often have multiple purposes, such as the bead chains which build on one-to-one counting, **then** into skip counting and early multiplication concepts and can also be used to construct polygons. Later the bead chains become part of a decanomial study involving cubes and squaring. From her understanding of the hands as instruments of man’s intelligence, Maria Montessori created the hands on manipulatives to help construct then test a child’s understanding, evoke their imagination and aid their understanding of abstract ideas. **Didactic** originates from the [Ancient Greek](http://en.wikipedia.org/wiki/Ancient_Greek) word διδακτικός (*didaktikos*), which "related to [education](http://en.wikipedia.org/wiki/Education) and teaching", and despite scholars in the 19th  Century attaching negative, moralistic connotations to the word, its original intention was that learning took place in a fascinating and intriguing manner (wikipedia). While pure mathematics includes the study of patterns, structures and relationships, in Montessori education, the “things” become less important than the way and the why.

### The materials need to be self-correcting and age-appropriate. The use of colours guides the child (e.g., colours used to separate ones, tens and hundreds are the same in the ‘stamp game,’ squaring board and rack and tubes.) Materials are also assist in the development of motor control, concentration, engagement, precision and the development of all 8 senses (Thermal, Baric, Stereo-graphic, Visual, Gastronomic, Olfactory, Auditory, Stereo-gnostic). Through modelling and connection the child learns to treat the materials with great respect. According to Nicky Chisnall, in the use of didactic materials, Maria Montessori provided for the following - development of the intellect from concrete understanding through to abstract, refinement of senses and orientation and adaptation to earth as our home environment (Chisnall, 2005).

Maria Montessori coined the phrase “the mathematical mind” to refer to the part of the mind that deals with logic, order and abstraction and allows us to understand our world. Mathematics is therefore useful to train and develop this mind and provide training for rigorous thought. It also provides the process that enables a child to understand the following essential principles… (Lock, 1997)

Conservation - example: equality of two equal things remains even if their appearance or spatial arrangement changes. This applies to a range of mathematical measurements such as length, area, weight and number. The Yellow box material is an example of Montessori math material that assists with this concept.

Reversibility - an action or operation than can be reversed/done and undone, example: liquid poured from a long, thin container into a short, thick container can be poured back into the original container, restoring the original situation. Children in Montessori pre-school would experience this in pouring exercises and using addition strip boards reveals that 6 + 4 = 10 and 4 + 6 = 10 at a higher level.

One-to-One Correspondence (and ordinality) - The process of pairing members of a set to another one at a time, example: A number word is said or one item only. Cards and counters are an example of Montessori math material that assists with this concept.

Seriation and Transitivity - These concepts refer to grading (by size, colour etc), and to generalizing the idea of grading objects. Cylinders and blocks enable a child to grasp this early on along with the colour tablets which have increasingly subtle gradations.

Cardinality - The ordinary numbers (1,2,3,4,5), and the understanding that the last number used is the total number; when counting the 3 number rod, you count out all three number words, and the last word is three which is the sum and the ‘name’ of that particular rod.

The study of mathematics is much more than the acquisition of mathematical skills, it is about connection and the child explores through their hands and senses with support. The main role of the Montessori teacher in mathematics is that of observer, one who knows the child maintaining the environment (including the hidden curriculum/class culture) and to encourage independent individualised learning at the child’s appropriate level of challenge, intellectual curiosity through such means as stories and cosmic connections in lessons, self-motivation. self-correction and freedom with responsibility.

The curriculum is the concepts the child can learn from the material, the delivery is how the materials are accessed and presented, the pedagogy is the way cosmic education is an integral part of the presentations and interactions and the philosophy (Montessori’s scientifically evidenced understandings) is why Montessori meets the needs of the child and promotes peace education. The child does not need external rewards but gains immense satisfaction from their achievements and completing meaningful work that they have usually selected for themselves.

Through Montessori maths, human tendencies are satisfied. Theses are our inbuilt schema and needs as humans, regardless of culture. These predetermined tendencies cause us to think, act, behave, or progress in certain ways. These are characteristics that we display naturally. Maria Montessori identified them through years of observation and they include our need for the following…

Abstraction, the ability to think and imagine, to carry ideas and elaborate on them through visualization and plan and set goals

## Activity, movement for its own sake and for independence or a specific purpose

## "Movement, or physical activity, is thus an essential factor in intellectual growth, which depends upon the impressions received from outside. Through movement we come in contact with external reality, and it is through these contacts that we eventually acquire even abstract ideas." (*Montessori, 1966)*

Communication, the ability to express thoughts, feelings and information through various means and for a variety of reasons

Exactness, precision and accuracy that brings satisfaction and a sense of beauty

Exploration, using senses to experience the world, make discoveries and make sense of things

Manipulation, using hands as tools to explore the world and take hold of the environment to understand it, using that which is around us

Orientation, how, why and where we belong

Order, this assists with a sense of security and can be internal and/or external. A properly prepared environment is an example of satisfying a child’s need for order externally

Perfection, mastering mind and body as tasks are mastered to the point of personal satisfaction and often in deep concentration

Repetition, carried out sometimes to achieve mastery and independence and at other times for security or pleasure

Work, generating feelings of worth and satisfaction, accomplishment, self-respect as the child constructs self in a purposeful way

Throughout history, these tendencies have driven human actions and Maria Montessori allowed for all aspects of these to provide children with the best environment in which to construct themselves. She believed that, “If an educational act is to be efficacious, it will be only that one which tends to help toward the complete unfolding of life. To be thus helpful it is necessary rigorously to avoid the arrest of spontaneous movements and the imposition of arbitrary tasks” (Montessori, 1964).

Maths provides more than a pathway to navigate a lifelong journey, woven through with myriad other pathways in the past, present, future, the universe and the natural world into a connected whole. It is part of what Montessori calls cosmic education. This education is about human endeavour, belonging, a deep sense of gratitude, self-construction of individuals and making sense through continuous exploration and discovery.

\* see Non-verbal response for illustration of this ‘connectedness’.

Commentary on the image (non-verbal response)

Cosmic Education is a multi-layered, multi-faceted concept. I have attempted to represent this through layering images of galaxies with a fingerprint between them. This acknowledges that the child is a unique part of the universe and the universe is part of the child and because the hands are our tools that we manipulate materials with to build our understandings.

The fingerprint represents the individuality and 'uniqueness' of the child and that their understandings, experiences and needs will differ; that we need to 'follow the child' as they are at the centre of constructing themselves.

In each space between the swirls of the galaxies is things from man-made (culture and constructions/cities) and natural worlds, representing mathematics connects completely (to both) - structure, form, patterns, relationships. They are like pathways - a part of life's journey as we seek to understand them and make sense. The paths widen to illustrate how knowledge widens and it goes off the page without a frame to allude to the fact that we still don't know all there is to know, the possibilities are infinite (another mathematical concept!).


In the foreground is our world, our immediate environment and how tightly we are linked to it and that we are all in this together. We need to understand it unravels if we don't connect to and care for it. The yellow spiral is both a representation of patterns and relationships like Fibonacci (and the golden ratio), and the life we have that is dependent on the world and the life force of the sun. There is also balance to remind us of how fragile, awesome (in the true sense of the world) and mysterious our universe is.

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