The Mathematical Mind

Introduction
Maria Montessori, her many colleagues and collaborators observed many spontaneous and unexpected revelations about human development – revelations which emerged universally, across time and geography, within the Prepared Environment of the Casa dei Bambini. Montessori’s work centers on these universal characteristics of being human. This topic, ‘The Mathematical Mind’, describes one aspect of these universal human characteristics – specifically: that the human mind develops and functions “… with exactitude”. To describe this exactitude of the human mind, Montessori borrowed the term ‘Mathematical Mind’ from the French philosopher, physicist and mathematician Blaise Pascal (1623-62) who described the human mind as “mathematical in nature”. In The Absorbent Mind, Montessori writes:

In our work we have given a name to this part of the mind which is built up with exactitude... we call it “the mathematical mind.” I take the term from Pascal ... who said that man’s mind was mathematical by nature, and that knowledge and progress come from accurate observation.¹

From a Montessori perspective, we can generalize that in the First Plane (ages 0-6), the Mathematical Mind functions without awareness as the Absorbent Mind. From the second plane onwards, the Mathematical Mind operates with awareness – as the reasoning, imaginative mind; this aware Mathematical Mind drives all progress in human knowledge and experience – we could think of it as the engine of the ‘supra-nature’, resulting in all of the achievements and inventions of the creative imagination, both scientific and aesthetic, from the most practical to the most transcendent.²

¹ The Absorbent Mind, (1949) Claude A. Claremont, trans. New York: Dell Publishing, 1967, ‘Further Elaboration through Culture’ p. 185. In Discours sur les passions de l’amour (1653), Pascal wrote: “There are two types of mind ... the mathematical, and what might be called the intuitive. The former arrives at its views slowly, but they are firm and rigid; the latter is endowed with greater flexibility and applies itself simultaneously to the diverse lovable parts of that which it loves”. Pascal and Montessori are not alone in identifying this universal phenomenon of the human mind. Two examples from contemporary literature come from Keith Devlin (the NPR ‘Math Guy’) in The Math Gene: How Mathematical Thinking Evolved and Why Numbers are like Gossip Basic Books: 2000: “The human mind is a pattern recognizer. ...The ability to see patterns and similarities is one of the greatest strengths of the human mind. ... What kind of patterns? ... visual patterns, aural patterns linguistic patterns, patterns of activities, patterns of behavior, logical patterns, and many others. Those patterns may be present in the world, or they may be imposed by the human mind as an integral part of its view of the world, p. 60; pp. 186-7; and Nassim Nicholas Taleb The Black Swan: The Impact of the Highly Improbable Random House: 2010: “Our minds are wonderful explanation machines, capable of making sense out of almost anything, capable of mounting explanations for all manner of phenomena, and generally incapable of accepting the idea of unpredictability.”, p. 10. Devlin and Taleb are also hinting here the truth that this Mathematical Mind can and frequently does come back to bite us!! (See p. 4 below)

² There is undoubtedly a limit to the ‘self-awareness’ of the Mathematical Mind as an “explanation machine” at any age, as suggested by the previous quotes from Devlin and Taleb. The essential point here
At any age, Montessori specifically links the exactitude of the human mind – this Mathematical Mind – with several life-long Human Tendencies working harmoniously together, including

Order:
Montessori describes Order as forming the basis of the human mind. She states that “… the form of man's mind, the warp into which can be worked all the riches of perception and imagination, is fundamentally a matter of order”. 3

Abstraction and Imagination:
Montessori tells us that Abstraction and Imagination “… play a mutual part in the construction of the mind’s content. … Of its nature, the mind not only has the power to imagine (i.e., to think of things not immediately present), but it can also assemble and rearrange its mental content, extract – let us say – an “alphabet of qualities” from all those numberless things that we meet in the outside world. 4

Exactness:
Montessori highlights the significance of Exactness for the Abstractions which form the basis of the Imagination, stating that “… abstract ideas are always limited in number, while the real things we encounter are innumerable. These limited abstractions increase in value with their precision. In the world of the mind, they come to have the value of a special organ, an instrument of thought which serves to give us our bearings in space, just as a watch gives us our bearings in time.” 5

Montessori seems to summarize the action and interaction of these Tendencies in the following:
If we study the works of all who have left their marks on the world in the form of inventions useful to mankind, we see that the starting point was always something orderly and exact in their minds, and that this was what enabled them to create something new. Even in the imaginative worlds of poetry and music, there is a basic order so exact as to be called “metrical” or measured. 6

is that as the mind matures from age six onwards, it can intentionally decide to explore and analyze specific experiences in the environment to the exclusion of other available experiences, whereas the first plane mind seems to lack such discriminatory specificity.

3 The Absorbent Mind  p. 185
4 The Absorbent Mind  p. 184
5 The Absorbent Mind  p. 184
6 The Absorbent Mind  p. 185. To be ‘mathematical’, then, is not necessarily the same as ‘being good at math’; and it does not necessarily the same as having well-developed skills in arithmetic: instead, to be mathematical is a natural and universal characteristic of the human mind itself – a birthright of every child and the characteristic mind of every human being, of every time and culture.
**Characteristic Activities of the Mathematical Mind**

We can identify three characteristic activities of this universal human mind – activities characteristic of the Mathematical Mind in action at any age:

- Accurate and Detailed Observation
- Discovery of Relationships between and among what is Observed
- Creation of Orderly Patterns from what is Observed and Discovered

Let’s look at these characteristic activities in a little more detail –

**Accurate and Detailed Observation**

We are curious creatures: curiosity drives us to exploration of all types and curiosity drives us to understand the world around us in all its aspects. This stimulates essential questions such as why? … how? … and what if? Such questions fuel scientific inquiry, the continuing quest for new, more accurate, or more complete knowledge [science from _scientia_ knowledge; _scire_ to know].

As a characteristic of the Mathematical Mind, Accurate and Detailed Observation is a touchstone of knowledge, a tool which can separate reliable, verifiable knowledge from surrounding ignorance, prejudices or beliefs. As already noted, Montessori cites Pascal in his assertion that accurate Observation is the source of knowledge and progress. Curiosity impels us beyond the presumed, the comfortable, the safe world, beyond predictable and rigid expectations and behaviors, and accounts for the expansiveness of human intelligence. Accurate and Detailed Observation is the mind’s tool to channel, focus and contain our natural curiosity.

**Discovery of Relationships Between and Among what is Observed**

Through observation, the mind seeks and detects the relationships that exist between and among what is observed – relationships in the world of concrete experience as well as relationships in the world of ideas, abstractions, and the imagination. This discovery of relationships is an important expression of the Mathematical Mind at work. For the child in the First Plane – the Sensorial Learner who ‘wraps her hands’ around concrete experience in order to learn – the first relationships are between and among objects, phenomena and people in the immediate environment. As the mind fulfills the progression towards Abstraction, however, a great leap becomes possible: the progression to relationships among those Abstractions, which forms the basis for the reason and the imagination of the Second Plane child who learns by ‘wrapping her mind’ around the world. The Discovery of Relationships among the abstract qualities of the world is a hallmark of the reasoning mind which emerges as the Absorbent Mind fades.

Most obviously, this awareness of relationship among Abstractions is essential in formal Mathematics, which has been described as a ‘Science of Relationships’. But the Discovery of Relationships is also essential to the Creative Imagination, which conceives Relationships not readily or immediately apparent. I have already cited Montessori’s assertion that Abstraction and Imagination “play a mutual part in the construction of the mind’s content”. It is important that the human tendencies for order and exactness are simultaneously cultivated to create a balance between Abstraction and Imagination in this construction of the mind’s content.
What do we mean by a balance between Abstraction and Imagination? We mean that the exactness of the Abstractions organized in the mind is a proper check on the limitless power of the Imagination. Montessori notes that “...the effort to cultivate imagination alone must lead to a lack of balance which becomes an obstacle to success in the practical things of life”. The Imagination depends upon the validity of the mind’s Abstractions to sustain and structure its creative leaps. On the other hand, Abstractions in isolation do not make for a lively, expansive Intelligence: the Imagination is also needed – to fuel the creative interplay among discovered relationships so crucial to the activity of the Mathematical Mind.

**Creation of Orderly Patterns from What is Observed and Discovered**

As relationships are discovered, patterns are forged out of the chaos of experience. The mind will weave intricate tapestries of pattern from any raw material, weaving them onto that warp of order “… into which can be worked all the riches of perception and imagination”.

In addition to the formal sciences, riddles, puzzles, word games, and evolving language; optical illusions, games of chance, astrology, meteorology; myths, metaphors, music and dance are all just some of the universal examples of this untiring characteristic of the Mathematical Mind to seek, discover and create patterns of order out of the chaos of our experience in the world. We organize our knowledge, find points of similarity and difference, categorize, and hypothesize; when we find ourselves carried away from the safety of the predictable and the known, pattern-making recreates safety out of the chaos of the unknown.

Ideally this characteristic works from Accurate and Detailed Observation: it allows us to extract universal principles which apply to a multitude of individual phenomena and thereby gives us tools and guidance for further action. But a caution is essential here: we need to be aware that this capacity to make order out of chaos is relentless – we will seek and find a pattern regardless of the circumstance. The resulting pattern, however, is only as reliable as the information it is based on. There are numerous examples in the history of human progress on this planet of incorrect patterns being deduced from insufficient, illogical, inaccurate or prejudicial data.

Here is one example, from the history of medieval Europe – with tragic consequences: during the great plagues of the 14th century, the Christian population of Europe reasoned that Jews were causing the deadly disease by poisoning wells, and subsequently persecuted the Jewish population for these ‘crimes’. Here is one historian’s account of that inaccurate and tragically deduced pattern.

A partial explanation may be that many wells in built-up areas were polluted by seepage from nearby sewage pits. The Jews, with their greater understanding of elementary hygiene, preferred to draw their drinking water from open streams, even though these might often be farther from their homes. Such a habit, barely noticed in normal times, would seem intensely suspicious in the

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7 *The Absorbent Mind*  p. 185
event of a plague. Why should the Jews shun the wells unless they knew them to be poisoned and how could they have such knowledge unless they had done the poisoning themselves?  

Bottom Line? The Mathematical Mind will relentlessly follow the perceived logic of observation, relationships drawn, and patterns deduced. The quality of our internalized sense of order, as well as the accuracy and completeness of our knowledge, become extremely important – not only for clear thinking but also, as we see here, for ethical behavior.

**The Mathematical Mind in the First Plane**

We see these characteristic activities constantly at work in children from birth onwards: the parallel learner of the first plane applies the solitary, maximum effort of ‘child work’ to these activities. They are essential to the formation of the personality during the first six years of life – a formation which occurs because of the Mathematical Mind working without awareness as the Absorbent Mind. The First Plane child

- Observes through a comprehensive, sensorial exploration of the real world
- Discovers relationships between and among the accumulated data
- Creates explanatory patterns based on what has been observed and discovered

All of this occurs without any selectivity or discrimination, and making no value judgments either in the choice of what to observe or regarding the resulting explanations. This is the absolute beginning point for each human individual in terms of the formation of the personality and its emergent intelligence. The quality of all that follows depends upon the quality of experience at this first stage. And even though the young mind makes no value judgments in the process, the mind apparently does unconsciously care about the accuracy of the explanation, and will gladly sacrifice any egotistical interest in ‘being right’ for that accuracy.

A simple anecdote – and true story – illustrates this point: A two-year old and his Grandpa are watching the dissipating lines of contrails left by invisible airplanes across a clear blue sky. Grandpa asks: “Do you know what those are?” The two-year old answers with complete confidence: “Those are the lines that make the clouds”. A precociously verbal toddler gives rare voice to the Mathematical Mind at work in the First Plane. Here is clear evidence of a typically invisible yet active mentality which has already observed a phenomenon – the sporadic appearance of long, white lines that gradually disperse high in a blue sky; spontaneously related it to another phenomenon which is already known and named – the appearance puffy, white, irregular clouds moving across the sky; and deduced a pattern of causal relationship – those

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**8 Philip Ziegler, The Black Death, Harper Torchbooks, 1971, p. 100**
dissipating straight lines must be the source of the clouds: a charming answer – charming, logical and absolutely wrong; and presenting a sudden dilemma for his grandparents – risk damaging a ‘fragile ego’ with a correction or abandon him to an illusion? Honesty wins out and Grandma says, “Actually, those are contrails; they come from airplanes so high in the sky we can’t see them”. The toddler considers this – he knows airplanes and has flown in them; with no fragility in sight, he simply responds, “Oh”. Apparently, Mathematical Minds value truth over ego and the deduced pattern is adjusted in his mind to new information.

Through countless events just like these, a child creates himself from birth. The reason for both this process and the importance of accuracy in the process becomes obvious: the deduced patterns represent a perceived external order which becomes the foundation for the internal order of the mind – in other words, the foundation for the intelligence itself, the “form of the mind” which (as Montessori stated) is “fundamentally a matter of order”. This internal order occurs as a progression from specific lived experiences to generalized abstractions held solely in the mind. As Montessori Elementary Trainer Kay Baker was heard to remark recently, “Experience precedes Abstraction”: there could be no better summary of the action of the Mathematical Mind in the First Plane.

The progression from lived experience to generalized abstraction is not mysterious – it is a journey every one of us pursued avidly in the unaware first years of life. Think about it: When did you create the countless abstractions which form your mind?

- Abstractions for the objects found in the built environment, such as ‘objects we sit on’?
  
  Repeated experiences in the external world of specific things people sit on became a generalized abstraction of ‘chair-ness’.

- Abstractions for sensorial qualities: for example, the relative heaviness of objects forged a generalized abstraction called ‘weight’

- Abstractions for the rules of language – example: in English, repetition of auditory patterns indicating plurals by adding the sound ‘s’ at the end of words became a generalized abstraction of how to pluralize any noun – including (at first) many ‘sheeps’

- Abstractions for other life forms: Repeated experiences of animal types generated abstract classifications such as dog-ness – equally identifiable in a Chihuahua and a Great Dane; or bird-ness, often first manifested when a member of the classification is linguistically mislabeled – all birds are called “ducks”

- Abstractions For emotional qualities – such as gratitude: specific experiences of people meaningfully saying “thank you” led to a generalized abstraction of gracious gratitude and how to express it according to the social norms of the surrounding culture

- Natural numeracy – specific, repeated experiences of counting five things of many types eventually supported the generalized abstraction that anything can come in sets of fives

Ideally, consistent, accurate and reliable experience will result in the most accurate, reliable and authentic abstractions possible in the mind. As driven by the unaware Mathematical Mind in the First Plane, the cumulative outcome of all this processing is cultural adaptation – the self-creation of a human personality completely adapted to a particular time and place.
The Mathematical Mind and Cultural Adaptation
The plasticity of this process – particularly in the First Plane – is universally recognized, even if it is not always understood to the depth characteristically found in the Montessori perspective. Its reality is proven through the phenomenon of cross-cultural adoption of young children – a commonplace of our global society in which a child becomes a person of the culture she actually grows in and not the culture of her birth.

In terms of human culture, every child from birth comprehensively and indiscriminately observes the specific activities of the people around her to discover the habitual patterns of their behavior. Montessori explicates this relentless process of cultural adaptation – all happening completely without the awareness of the child who creates the outcome – in powerful terms. She writes:

The child absorbs … from the world about him the distinctive patterns to which the social life of his group conforms. … He absorbs the basic or summarized part, the precise part, which … is repeated in the habitual life of the people. He absorbs in short, the mathematical part. And once the patterns have become established within him, they remain as fixed characters, just like his mother tongue. ⁹

Montessori labeled this absorption “incarnation” – a literal embodiment of these habitual patterns of behavior: the “fixed characteristics” of the external society become internalized structures of the personality. And Montessori definitively acknowledges the powerful outcome of this incarnation, elaborating that

… the pattern is something potent and creative, giving form to the personality in just the same way as hereditary features of the body are shaped by the genes … ¹⁰

Evidence of this incarnation, this creative formation of the personality through the characteristic activities of the Mathematical Mind, is omnipresent in all human societies. Yet, as with many universals, it is typically unquestioned, unnoticed and unrecognized by those who provide the models for the absorbed behaviors. Without it, the transmission of human culture in the built world of the supra-nature would cease – for the continuation of culture is possible only through the activity of the child who is driven by nature to seek, validate and embody accurate knowledge of the world he must navigate for his survival and his fulfillment.

Observation – Imitation – Incarnation
The application of the Mathematical Mind to become a personality fully adapted to her culture is most discernible in a child’s imitation of the habits and practices he observes in the people around her. The Mathematical Mind, it seems, is never idle; it uses any object or opportunity at hand to act out the deduced patterns of behavior observed in society, repeating them as best he can until the pattern is confirmed. This, then, is the source of a child’s ‘play’ – acknowledged by Montessori for its developmental significance and honored through the activities of a Montessori prepared environment by the term ‘work’. “It must be

⁹ The Absorbent Mind  p. 189
¹⁰ The Absorbent Mind  p. 189
remembered”, she tells us, “that most of the activities of the child, including play activity, are inspired by observation”. 11

There is no way to externally interrupt or re-direct the Mathematical Mind’s progression from observation to imitation to incarnation. In this context, then, we must look to the quality of the opportunities available for the child’s observation and imitation. The quality of the opportunity becomes paramount – for the quality of the opportunity directly affects the quality of the final incarnated pattern. For the maximum outcome, the Mathematical Mind hungers for the most reliable versions of the reality this child will inhabit. Yet too often this hunger is poorly and inadequately satisfied. Montessori clearly distinguishes those opportunities for activity which fail to nurture the goals of the Mathematical Mind. She identifies many objects typically offered to the child by the unaware adult as

... imperfect and unproductive images of reality. Toys, in fact, seem to present a useless environment which cannot lead to any concentration of the spirit and which has no purpose; they are for minds astray in illusion. 12

And she compassionately notes that

The baby finds all that he himself needs in the form of play-things made for dolls; rich, varied and attractive surroundings have not been created for him, but dolls have houses, sitting-rooms, kitchens and wardrobes; for them all the adult possesses is reproduced in miniature. Among all these things, however, the child cannot live; he can only amuse himself. The world has been given to him in jest ... 13

With this perspective on the child’s incarnation through imitation using objects in the environment, Montessori gives us clear criteria for evaluating anything made available for a young child’s activity. Its implications for child-rearing and for childhood education infuse the principles which characterize Montessori practice. This practice acknowledges that the power of the Mathematical Mind drives the child to absorb the “mathematical part” of culture in order to form his personality, and that a child thereby grows and develops through what are today described as ‘experimental interactions with the environment’.

These experimental interactions with the environment are at first conducted by the child Montessori characterized as “the unconscious creator” – the child from birth to approximately three years of age, a child pursuing experiences in order to create the characteristics of his time and place. As the child matures, however, energy diverts to the refinement and perfection (or completion) of these creations. Montessori characterized the child from three to six as “the conscious worker” (under the power of what she termed “the conscious Absorbent Mind”). She places this older first plane child in the “third embryonic period” for the formation of character and society. The personality will be completed in this third embryonic period, and by age six there will be a crystallization of the child’s individual character and his social life – all based upon

11 Montessori, What You Should Know About Your Child Clio: p. 77
patterns of action, interaction, attitude and belief he deduces and incarnates from observation and imitation of every aspect of the surrounding culture.  

The Mathematical Mind is active in a young child “from the first”. As with all universal characteristics, it can either be supported or thwarted. The Mathematical Mind develops as a child grows in knowledge and experience. And its development proceeds according to a definite and universal pattern.

Our goal as Montessori educators is to always support the Mathematical Mind of the young child – removing obstacles to its work and providing the best experiences possible for its fulfillment. The entire contents of the Montessori Prepared Environment of the Casa, and all of the experimental interactions possible there, can be understood and interpreted as materials and activities which optimally support the unaware work of the Mathematical Mind in the First Plane of Development.

One final thought from Montessori – describing here the mental formation which occurs because of this work of the Mathematical Mind in the first years of life:

These things taken together have brought to us the idea of a basic formation on the mental side of the child’s personality. A psychic organism is forming itself, and it does so on a pre-established pattern. If it were not for this, the child’s mental horizon would have to be fashioned by his reasoning and his will, that is to say, by powers that are not acquired till later on... Just as a man does not create his body by logical reasoning so he does not follow a line of argument when creating the form of his mind.  

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14 Absorbent Mind, p. 242
15 The Absorbent Mind p. 190
Works Cited


Maria Montessori What You Should Know About Your Child Clio Press


Philip Ziegler, The Black Death Harper Torchbooks, 1971