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TEN 10 YEARS

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Contents

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From the Editor

The European *Journal of Montessori Research & Education* (*MoRE*) editorial team is pleased the publication is joining the *Journal of Montessori Research* (*JMR*). This collaboration represents a significant milestone for the Montessori movement in both Europe and the United States, as it opens doors to a unified research platform that can benefit researchers, policymakers, practitioners, and the media in various ways.

With expanded international resources and knowledge, researchers benefit from a shared database and fee-free article processing, policymakers get open access to empirical studies to inform their decisions, practitioners have a peer-reviewed resource supporting their work, and the media can gain a clearer and more comprehensive understanding of the advantages and challenges of Montessori education.

In a complex world, Montessori education holds unique potential to contribute to the conversation about building a more positive future. Montessori education offers real examples of doing education differently through an emphasis on sustainability, interconnectedness, experiential learning, and fostering young people's initiative.

In this special issue, we present previously published *MoRE* articles that we consider valuable to republish in *JMR*. This collection serves as an introduction to the new collaboration.

The editorial team at *MoRE* looks forward to embarking on this journey, confident that this combined publication will create new opportunities for the Montessori movement as well as society at large.

Sincerely,

Eva-Maria Tebano Ahlquist
and the editorial team of *MoRE*

Ongoing American Montessori Society (AMS) financial support for the Journal of Montessori Research *makes open access possible without requiring authors to pay article processing charges.*

The "Cosmic" Task of the Youngest Children — Direct, Anticipate or Respect? Experiences Working with Small Children

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Keywords: *Maria Montessori, Adele Costa Gnocchi, day care, small children, Montessori materials, teachers role, Cosmic task, neuroscience*

Abstract: The article derived from Grazia Honegger Fresco's years in close cooperation with Maria Montessori and Adele Costa Gnocchi. The author illustrates how small children from the moment they start using their hands and are standing unassisted on their own legs must act in their own way. The teacher must observe before acting and intervene as little as possible. Honegger Fresco follows the work of Montessori and Costa Gnocchi and she compares the findings with different fields of science, such as ethnology and neurology. As a result of her observations and experiences she points toward the relationship between a good childhood, and in the long term, human responsibility on Earth, using the concept "the Cosmic Task".

The method in this article is based on autoethnography, as the author shares her personal experience and reflections, both as a teacher and as an educator. The aim is to shed light on aspects regarding the needs of small children and to point at the essential role of adults, educators as well as parents. As Schiedi explains, autoethnography "extends its narrative horizon to a social, professional, organizational dimension of the self" (2016). During Honegger Fresco's career, she was primarily inspired by Maria Montessori's research about child development and children's needs and rights, and she had continuously deepened her understanding by studying other researchers in this field. Thus, the article will share her conviction that by serving the creative spirit of the youngest children we will build a better future for our planet.

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Introduction

It is important to recognize the important transformations and expressions of the self that emerge in the first years of every human beings' life. From ancient times, we have been led to believe that the first years in the life of a human being are of little significance. Instead the emphasis is placed on when children begin elementary school and when they, as adolescents go on to secondary school and later up to university. However, previous research in ethnography, psychology, neurology – from the beginning of the twentieth century until today – would suggest the opposite. Maria Montessori (1870–1952), in particular, had stressed the importance of the early years.

> *[S]ociety must heed the child, recognize his rights and provide for his needs. Once we have focused our attention and our studies on life itself, we may find that we are touching the secret of mankind, and into our hands will fall the knowledge of how it should be governed and how helped.*

In this article I will discuss that the way we act and communicate in the first years has an essential and very concrete part to play – completely observable – in the construction of the future adult's intellectual and physical abilities. I will try to illustrate in this, as the fruits of many years of work in the schools of Maria Montessori and Adele Costa Gnocchi, how every little one, boy or girl, from when the child is born until the point of being secure on two feet and capable with their hands – completely without knowing it – act as a milestone along the road of our species and the history of humanity. From the very beginning, this littlest one carries out their own special task that emerges with particular evidence in the second year of life. According to Montessori, children are capable of achieving their proper conquests independently and are actively learning from birth, that are, if their ability to concentrate is protected and they are allowed to work in their own unique way. Montessori (1989a, 1994, 2011) called it a "cosmic task". Humans have a responsibility towards the biosphere and the protection of all living species. An understanding of this task is not suddenly acquired in adulthood, rather, it must be built, step by step, from birth. This is done by respecting the child and promoting all their potential and independent growth. The way we act and communicate with children in the early age plays a key role in the manual and intellectual abilities that the child will develop as an adult, for example, to learn how to interact with other people in a peaceful way.

I will cover the neonatal phase and the first months of the child's life, but as the "cosmic" task can easily be identified during the second year of life, the foci of this article will be on that period.

Setting the stage

Between the 1910s and the 1950s, Montessori did numerous studies that focused on the period from birth until the age of three of the "long human childhood". These studies were carried out at Scuola Assistenti all'Infanzia Montessori (AIM) in Rome, which focused on the innate capacities that children developed in this age span. The school was founded by Costa Gnocchi (1883–1967). Costa Gnocchi[1] had been a disciple of Montessori since 1909 and accompanied her to many conferences and courses. She had done experiments at a Casa dei Bambini, at an elementary school and even at a lower secondary school. Costa Gnocchi managed to influence others to devote more attention to the early developments (from birth) of children. In 1947, in cooperation with Montessori, Costa Gnocchi founded the Scuola Biennale AIM, which aimed to educate young women in the bio-psychic care of newborns and to help parents on how to read and how to respond to the child's non-verbal signals. The Scuola Biennale AIM offered a three-year program that combined theoretical studies with practical training. Certain parts of this three-year program focused on the newborns. There was also a two-year track that prepared the students to take care of slightly older children, either at home or at some educational institution. In 1958, the Scuola Biennale AIM was transformed into a state school. In this process, unfortunately, the institute lost its focus on the smallest children, which Montessori had put such emphasis on during the first ten years of the institute's existence. For this reason, Costa Gnocchi wanted to establish another institution, independent from state control, in order to conduct research on this age span and continue to give guidance to families regarding their smallest children. This idea was materialized in the form of the Centro Nascita Montessori (CNM),[2] which first opened its doors in 1960. Costa Gnocchi borrowed the name from the 7th Montessori Congress, which took place in Edinburgh in 1938. The theme of the congress was "Education as an Aid to Life". For Costa Gnocchi, who attended the congress, it was self-evident that this "aid" should be given right from birth. Therefore, as a

motto for the CNM, she rephrased the name as "Education from Birth as an Aid to Life".[3]

This period from the 60's was, however, permeated by prejudices and critique of Montessori's ideas. The roots behind the difficulties to implement the new ideas were based on people's old prejudices, sometimes dating back to their own childhood which they had to overcome before they could begin to trust the children.

> *In order to have valid observations, it is necessary to allow the child to manifest himself. If we put a cage around him, the bars in the bed and so on, his manifestations will be false. There is a need for a suitable environment so that the child can act naturally.*

Teachers needed to find a new interest in their work and begin to understand how complex and delicate this work is, even though it cannot always be detected by the naked eye. So much research and practical experience were thereby kept out of the public discourse. It was not until the late 1990's that the idea, albeit slowly, of a Montessori daycare[4] began to gain traction in Italy, although often with adaptations and compromises to the original ideas. It often promoted a rigid imposition on the ways of acting by constantly seeking attention from the adults and there were frequent attempts to push the smallest children forward, not allowing them to fully live each stage, especially the first thirty months. The children were thereby put in a type of elementary school before they have even gone through the formative climate that characterizes the period from zero to six years. It is important to note that Montessori's main idea – to observe the child and follow them, not to stress to teach them something but rather to be at the service of their development and inventiveness – has thereby been neglected or put aside. There is a very delicate choice for the teacher to resolve the conflict between the unknowns coming from each child and the need for security which is typical of adults and between the multifaceted need to explore continuously in the early years and the adult's immobility.

My own experience and contribution to further development

In 1949–1950, having just graduated from AIM, I worked as a teacher in the "Scuoletta" of Palazzo Taverna, which was directed by Costa Gnocchi. There I followed a dozen children who were between fourteen and thirty months old. I organized some games, but I told myself that I needed to do more for these children. Therefore, I began to design different types of objects that each corresponded with different observable needs amongst the smallest children. The objects that I designed were variations of "inside- and outside-"activities, which corresponded to small children's passion for putting things into holes.

Inventing objects for small children

The first piece I built was a large dowel with rings. I made it by attaching the end of a broomstick to a wooden disk (six inches in diameter and three quarters of an inch thick). I put three wooden curtain rings on the dowel. The invention became a great success, the children (fourteen to sixteen months) carried it around and now and then they stopped, removed the ring and put them back again, each time with great care. This encouraged me to create other things such as simple wooden shapes cut out with a jigsaw and inspired by the Flat Wooden Insets,[5] just one or two circles with large knobs for easy grasping. For the older children, thirty months and more, I made cardboard boxes that they could glue images on, which is so important in the development of speech. We also constructed a frame with just three buttons on, a simple invention which was recently proposed to the children in the second year of a Montessori "Mother and Children"-center in Sochi (Russia).[6] Throughout the 1950s and 1960s, one of Adele Costa Gnocchi's students, Laura Benedettini Bolasco, designed, produced and sold many new types of materials. Some of these were even bought by Americans who had come to Rome to study the new methods for the youngest children. It was common practice thereafter in our training courses for 0–3 educators for the students to develop their own handcrafting abilities in order to respond to the needs of these youngest children. Inventing and creating educational materials is an excellent opportunity for adults to reflect on children's motor development in this phase of life.

Since the 1990s, with the spread of the "nidi", various manufacturers started to produce Montessori objects that were designed for the smallest children; smart games, that were beautiful to behold and much appreciated by the smallest children. However, the children in the second year did not only lose interest in our more modest home-made models, but also in the perfect ones made in a factory. Therefore, we started to ask ourselves why they lost interest. If we could find the answer to that question we could invent new ones that were more adapted for that age.

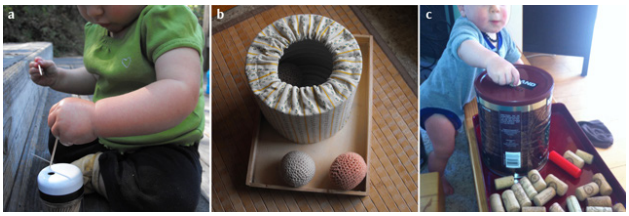
A change of direction

Already my first experience of the children that were in their second year, showed that their actions were repetitive but never mechanical. After a number of observations, I realized what was typical of a certain period in their development, the period that occurs right after the children have developed the ability to grasp an object, drop it, pick it up, shake it, and shake it in a container. For example, the spoon in the cup, which they had seen me use, but I did not know that would trigger them to try to do the same. After the children had learned a new thing by repeating it several times, they usually thought of similar activities that they also repeated several times. In the beginning, I had not reflected enough on the children's capacity to invent, this had led me – as I wrote above – to create objects that facilitated one type of action. In a certain sense, however, they recognized them a priori. I understood that my homemade inventions directed the children too much. If the children were not shown in a direct or evident way what to do with each object, they began to use them in many different ways. Sometimes they watched each other, but often the children began to play and experiment with the object in their own personal way. Each time, there was a binary rhythm in their actions: "in and out" with an object out of a box, then after a couple of days, they changed the order. This was true with all their actions; push and pull; fill and empty; etc. One example of this was "the key in the lock"-action. They used a small stick as a key, then they used it on the radiator, on the cabinet or on the apples that were just brought to them from the kitchen. Each variant of this activity was carried out for a long time, up to 30–40 minutes of careful concentration. When they changed from one variant of the action into another they took a long pause and moved around in the room, observing the other children, while they were continually looking for a new action to do.

One example of this, which was found in a family, was when Sam,[7] 16 months, had found a flat wooden strip. He first began to put it between the empty spaces of a chair, then in the holes of a net, between the books in the shelf. After a while, Sam found a handful of coins and began to insert them between the DVDs and some others he put back into their vertical container. A few days later the parent found out that the DVD player had stopped, the technician revealed that the mysterious malfunction was due to the fact that the recorder was full of coins – all done by our innocent busy explorer (Figure 1a, b, c) who only follows his own internal command. It is evident that children are equipped with an "esprit mathematique",[8] just like Galileo, they are deeply absorbed in their explorations of the world through a game of trial and error, each time modifying their experiments after their own head. They learn a new action and after a while, they move to the next one. Therefore, to preserve and promote this innate ability to explore, it is better to make available objects and materials that are "unstructured" and not too direct.

Figure 1

Busy explorer. Photo by Karin Slabaugh.



From the 1980s, the provincial administrations were responsible for educating the staff of the municipal daycare. In a series of fortunate circumstances, I was offered to participate in the education of the daycare staff in Varese, the city that I had just moved to from Rome. The group responsible for the education of the daycare employees mostly consisted of medical doctors and psychologists, they were all very good at theoretical aspects but they were lacking in the more practical aspects. Following the example set by Costa Gnocchi, I avoided the lecture-style of teaching, instead, I encouraged questions and discussion and tried to make the topic more concrete and practically applicable. In the courses for teachers who would work with children between the age of 0–3, I focused on how to plan, compose and build,[9] and how to respond to the needs of children. Much focus was also placed on how to stimulate an interest in simple but gratifying craft skills. Later on, this became a common practice in these courses because it is an excellent way to begin to reflect on the various expressions that occur through acts during this stage of children's development.

The first daycare that really understood the importance of observations and to respect the small children was the daycare Caronno Pertusella, near Saronno in Lombardy. In two years, through the strength and persuasions of the educators and with the help of a particularly agreeable councillor, they managed to transform Caronno Pertusella from a heavy ONMI[10] structure into a pleasant place that put the needs of the children at the heart. Other day-nurseries in the Varese region also began to adhere to some of the examples, set-out by myself and the daycare in Saronno, by focusing on the Montessori-mode of observing the signals that are coming from the chil-

dren. Together with some friends, I founded the Association, "Percorsi per Crescere".[11] In numerous municipal day-nurseries, our ideas began to gain traction but the process of change was however, slow.[12] Step by step, from the coordinator to the assistants and the cook, the winds of change were spreading, although it could take two or three years and sometimes even more.

Developing children's capacity to concentrate

In the late seventies, many day-nurseries began to use the so-called "basket of treasures", which worked for both children who were sitting alone and for children who were just starting to stand up. The basket of treasures was the brainchild of Elinor Goldschmied (1910–2009),[13] the brilliant observer of the smallest children. Each object in their basket had its own "raison d'etre", and it could be simple household objects that could be found at home.

> *Children in their second year feel a great urge to explore and discover for themselves the way objects behave in space as they manipulate them. They need a wide variety of objects with which to do this kind of experimentation, objects which are constantly new and interesting, and which certainly cannot be bought from a toy catalogue.*

The heuristic rules[14] were to gather a large collection of unstructured materials in the basket, and later on, these objects could be combined together and then rearranged. This procedure always fascinated the small children. However, we preferred, as was our usual practice, to give the small children even more freedom to explore and try to minimize the interference from the pedagogues. To reorganize the objects in their original place (before lunch or at the end of the day) was sometimes a challenge but never a problem. Even from an early age, these children are starting to grasp that every object has its own place and should be returned there. This proves that even the smallest children have a biological need for order. Montessori has even spoken of a sensitive period of order (Montessori 1956, 1966).

All of the above-mentioned day-nurseries continued to experiment but in their own individual way. At the Germignaga, for example, they were particularly skilled in games with different types of wood, whereas the day-care in Saronno used an object from every day-life more frequently (sometimes the parents brought materials from their workplace). At another daycare in Cassano, the entire group of educators was committed to finding the type of materials that was best for children and used a constant order in the environment as their main source of developing a tranquil atmosphere. In Cardano, we witnessed how effective the use of unstructured materials can be and how they always approached the children with intense concentration and respect. Also in Rome, in the day-nurseries, which were managed by CNM, they began to emphasize the use of different types of materials.

One thing that Elinor Goldschmied recommended was that the child needs the stable presence of seeing the same educator. Just like the parents, the educator thereby becomes a clear reference point for the child. The importance of the children's need for a stable adult presence was also shared by another scholar, the Hungarian Emmi Pikler (1902–1984).[15] Pikler was a pediatrician and had founded the Institute at via Lòczy in Budapest,[16] which was an orphanage that ensured that children received a normal development similar to that it would have had in a family. Pikler had studied the motoric development of hundreds of children when they were being cared for by just one adult educator. In this case, one educator took care of three children, and was thereby very present – through words and actions – but at the same time gave the child total freedom to move and explore within a restricted protected area.

> *Our studies contradict the widespread opinion, seen also in many reports, that the adult's direct help is necessary for children to acquire the basic and transitory motor developmental skills and for being active in gross motor activities. The adult's support and teaching or help may hinder to a certain extent the continuous gross motor activities of children.*

An important revelation brought to light by the work of Goldschmied and Pikler is that the close relationship between adult and child should be guided by a conscious and rigorously prepared adult. This preparation should focus on the intellectual protection and 'nurturing' of the child. This is true for all the hours of the day when the child is awake when the child is exploring with their hands or moving its body, it is all about a child that is capable. Regarding the very first years of a child's life, Montessori (1998) speaks of the importance of continuity in sensory and affective experiences and she emphasizes a thousand ways of non-direct intervention by the adult. For me and my colleagues at CNM Percorsi, and the coordinators and directors of most attentive day-nurseries, we have gained tremendously from the contribu-

tions of Goldschmied and Pikler. In particular, how they highlight the importance of developing children's capacity to concentrate, and this cannot be enforced by adults.

Our experiences from working with the "heuristic" material were that it had a positive effect on the restless, bored, and aggressive children. Being able to do a repetitive action and later doing a variant of the same action according to their own time-table gave them a sense of satisfaction and was like a consolation. After a few weeks, the interaction these children had with other children became more peaceful and with less conflict. They also showed signs of a prolonged attention-span and their ability to concentrate on one task improved. They began to enjoy being alone at the table and after a while, they let go of some comfort objects (pacifier, safety-blanket, or puppet). They did, however, continue to use the comfort object at home, mostly because the adults used them at the slightest hint of conflict. Gradually they began to show that they could create different variants of the material/games and they were already quieter. Each of them did it in their own individual and original way compared to the other children in the group: slipping themselves into corners, under a table or in a box. They started to touch everything in an explorative way, creating what the adults would describe as a mess was for them a vital way of thinking and acting. However, they did this with great concentration and after it was done they showed signs of satisfaction.

Vagabond explorations

I want to call this phase of inexhaustible research in continuous movement when the small child goes everywhere – seemingly without thought or purpose – for vagabond explorations (vagabondaggio esplorativo). This phase of vagabond explorations expresses the great formative energy of the small child that will eventually develop into full autonomy as an adult.

I began to make less and less structured material available (and at no cost): cardboard tubes of various diameters and lengths; Bakelite or wooden rings (from curtains); large corks and curlers; small pine cones, shells or big walnuts; easy-to-open boxes, coffee cans with perforated lids; handbags, sacks, baskets etc. Together with my colleagues and friends, we made an interesting collection of objects. The objects – from 6 to 10 at most – were assembled each time in a suitable container after they had been used, to avoid that the exercise was duplicated the next time. Some unpainted wooden blocks that had been donated by a carpenter would be placed on a little tray; tongue depressors in a little basket and some small dowels in shoeboxes. We offered pieces of tubing of varying diameters and varying lengths of three to five inches to see if the children were interested in inserting one tube into another, which they invariably were. We would put out a small cloth bag with five or six horse chestnuts and a bowl next to it, and just as soon as we put it out, a child would come up and take out the chestnuts, put them in the bowl, return them to the bag and so on. We put several small pieces of fabric in a basket.

Every day upon his arrival, Claudio, a 23-month old boy that was often moody and sulky, would use these fabric pieces to wrap up some plastic animals from another basket. He would always choose the predators, the lion, the crocodile and the dinosaur, and would do the same thing every day. He would put them in a line on the shelf and not let anyone touch them. Only at the end of the morning would he remove the pieces of cloth and let the other children play with these animals. He did this for a month, every day, and then one day he stopped doing this.

It is not always easy for an adult to explain the profound motivations of the child's behaviors, but a keen educator knows that her principal task is to follow the child and observe him, without intervening, and never to prohibit a behavior except for obviously a concern for his safety.

Over the years, it became clear to me that the objects which were preassembled and had a beautiful design, for example, the box that resembled a drawer that had a ball which could be inserted into the box or the large pearls that moved alongside a metal wire from which they could not be removed, did not fully fill the explanatory impulse of the small children. The purpose of, for example, the box and the ball, was too limited and did not offer sufficient variations for the children's imagination. The box rather offered a monotone and even mechanical action. For this reason, the child soon lost interest. It is symptomatic of the small children's intellectual and curious soul that they are constantly seeking for a new thing to explore. A drawer box or toy that had wooden beads on a curvy metal rod attached to a wooden base,[17] can be of interest in the first phase of exploration but when they begin to experiment with the object in novel ways, more is needed to stimulate their explorative interest. For example, Sara, 10 months old, began to test in how many different ways a small plate can be balanced on her finger or Giulio, 20 months old, who started to explore what type of material – water, cornmeal or seeds – can fit into an empty container. Chil-

dren who arrive at the daycare that are around Sara and Giulio's age – ten to twenty months – are, in other words, starting to leave more structured games behind them and instead embark on more individual explorations. However, in some cases, the children move in the opposite direction and the reassuring repetitiveness of the games develop their attention span, rectifying their actions when necessary (innate ability to self-test) and learn to fully respect the games other children play. In observing the children, it is of absolute necessity that there is a shared reflection amongst the adults regarding the environment and organization where the children explore. The educators must, therefore, give the children ample space and a significant sample of different objects to explore (Figure 2a, b, c), among which the structured materials are a minimal part. Sometimes you hear educators complaining that the children are making a mess. This is true, especially when they are small. However, as educators, we must have patience and put the misplaced and abandoned objects back in their right place, because the children are observing the educators when they are tidying up after them. And step by step, if it is done in an affectionate and pleasant way, the children that are around 20 months old will begin to help the educators tidy up. The fact that the children begin to help to put the objects back into their right place is something we are used to as educators, but the parents are always surprised and amazed by this. It is not uncommon, for example in the already mentioned examples from Valentina, that two children tacitly invent a game together, creating a binary rhythm that is both calm and intensive at the same time. I stress "tacit" here because at this stage the children cannot communicate with words yet. A very interesting example of an integration between two three-year-old children was captured on photo by Margherita Vertolomo, coordinator of the Nido del Cedro, CNM, Rome.[18] The boy Roberto had a cardboard tube in his hands, the girl Susanna approaches and explores the tube together with Roberto, then she inserts some nuts into the tube, Roberto observes as the nuts go through the tube and fall out on the other side, he hears the noise and collects them and continues to insert them at the top of the tube again. The two children alternate this action and there is a harmony between them, they share a sort of wordless project. Other children come and go, but the shared project of Roberto and Susanna continues. After a while, they try to replace the nuts with some wires, but the wires do not seem to give them the same satisfaction, so they go back to the nuts. When we had objects of different sizes and length – large and small boxes, long and short; cylinders of various sizes, wide-mouthed bottles and curlers, shells, buttons, woody fruits collected in the woods, twigs etc. – the children often played together, even children of different ages.

Figure 2

Objects to explore. Photo by Margherita Vertolomo.

The alphabet of human labor

The repeated binary actions discussed above – in and out; open and close; fill and empty; go up and down (Figure 3); pulling and pushing; put apart and put together – is of the greatest interest for the children from the moment they are able to move. These actions refine the senses and are the first step towards more abstract activities. This phase, according to me, forms the basis of the complex actions that human beings are able to perform. It is the alpha and omega of human labor. We are "homo faber",[19] from the first year of our lives. No one suddenly receives their sharp senses and manual skills in adulthood without having been unconsciously prepared for this since childhood. Perhaps we have never noticed it, but many of the actions we do as adults are rooted in behavior that we have experimented with since childhood.[20] Recent ethnological studies have illustrated how this mechanism – which moves beyond simple imitation – is observable in different species, especially amongst primates. It probably began in ancient times when the humans formed the first words and continued to explore and invent different tools and art forms until the present day.

Figure 3
Go up and down. Photo by Karin Slabaugh.

No sensory material at the Nest (0–3)

On the basis of the observations made above, other colleagues and I strongly disagree with the many daycares that say that they use Montessori's method just because they have some sensorial materials at their "nest". In fact, these types of sensorial materials should be used at a later stage. It is true that, for example, Cylinder Blocks could be of good use in "inside and outside"-explorations. However, the same type of exploration can be achieved without using Cylinder Blocks or other sensory materials. The function of these types of materials is to make the child discover by using and exploring objects of different sizes and shapes, to explore similarities and differences between different objects. The children that are around two or three years old are not ready for this. We must be cautious against any anticipation as children do not need it. Instead, we should be waiting for them to reveal that they are ready to do something else. This can be seen, for example, in following the natural evolution of their experiences, when they spontaneously begin to make pairs or piles of similar objects, or to put rows with twigs, leaves, shells in order – from the largest to the smallest. When they do this, they manifest an entirely new interest and this change should be met by the educator adequately.

The Montessori daycare

The daycare for the smallest children is not a watered downed "Casa dei Bambini".[21] Some teacher presentations at the Casa dei Bambini are devoted to tasks related to "practical life" or the protection of the environment or the care of other people. Some presentations involve water, which is a material that fascinates many children. But before the child can wash a plate or handkerchief in water, they must go through a phase when they explore all the things they can do with water; to grasp the water coming out of the tap; see what floats and what sinks; explore the foam that is formed by a soap in water; to put things inside and then outside a bucket of water etc. Only when all this interest is exhausted, the children can begin to wash a doll, a plate or a dirty container A similar activity of discovery is the one with sand, earth or clay, long before activities of cultivation and watering of plants are undertaken. The same can be said of activities that are related to cooking or how to behave during lunch or snack-time. Before the children, who are three years old or more, can participate in cooking activities – that are often complex – they must have a matured security with these activities which is something they start to acquire when they are even younger. Amongst many educators working with children between the ages of 0 and 3, there is an idea that they should be preparing them for the next step (3 to 6). Since the little ones are not "yet" ready for the complex activities that will be offered, they are convinced that they must be trained in advance in order to be prepared to respond to the challenges that will come. Montessori always stressed the need to observe and respond moment by moment to the silent requests of the children, and this opinion was shared by the Jewish-Polish doctor and educator Janus Korczak.

> *You say:*
> *–Dealings with children are tiresome.*
> *You're right.*
> *You say:*
> *–Because we have to lower ourselves to their intellect.*
> *Lower, stoop, bend, crouch down.*
> *–You are mistaken.*
> *It isn't that which is so tiring. But because we have to reach up to their feelings. Reach up, stretch, stand on our tip-toes. As not to offend.*

Korczak (1992) recommended parents and teachers of the importance of the here and now of each child, to be respected without being held back or pushed. The experiences that children get right now can be a preparation for future tasks, but they should not be the basic criterion for deciding a priori what activities should be part of the curriculum. The most important thing is that

children are free to play and make their own choices in an environment that stimulates just this, without direct intervention by the adult. Obviously within reasonable limits: no material can be taken away from a partner or thrown at someone. This can happen at the beginning (new environment, the first distance from the parent and the like), but then it does not occur if the general climate is quiet, adults acting calm and not expressing judgments, preferences or comparisons. If the children have the feeling that they have free access to objects, they do not have to be introduced to the objects by the educators or adults. Because if this is not the case, as Elinor Goldschmied has said, there is a risk that the educators and adults "steal" the experience from the children. When the educators or adults are teaching the children to do this or that they are depriving them of the pleasures of discovery, and this pleasure of discovery is the only thing that leads a child around the age of three to achieve intensive concentration. Montessori has a famous example of this at the beginning of chapter three of her book The advanced Montessori method (1995).[22]

When it comes to opening and closing a tap, to bring a plate or to use a knife to slice a banana, the educators should do this slowly in front of the child, then they have to put the trust in the power of observation and "absorption" of every detail of the objects and actions that the small child possesses (Honegger fresco, 2011). Not surprisingly, Montessori spoke of "the absorbent mind", an intuition today fully confirmed by the discovery of mirror neurons (Ferrari, & Rizzolatti, 2015).

Sensitive periods in action

All of this focus on what these young ones do caused us to reflect on the timing of certain phases of child development, but there are, in fact, big differences from one child to another. To give an example, in Pido's daycare, two children arrived at the same time after spending 13 months with their mothers. One of the children, Sandro, could already walk with good confidence while Dino still crawled and made no attempts to stand up. Dino's mother asked worryingly after comparing Dino with Sandro if "he has to be able to walk?". The educator calmly reassured her and explained to her the importance of respecting each child's own development, which is all healthy in their own way. As an educator, we often have to reassure parents and explain that it is useless to make comparisons. Each child develops in their own time, due to different factors. Once again, it is not good to push the child by, for example, putting them on the ground too soon or being in the crawling-phase, depriving them of the amount of time that they really need. And when the child starts to cling or stand up – driven by a powerful internal thrust – it is important not to stop the child because of fear that they might fall and not to immediately put the shoes on.

Another important aspect to consider is connected to the two parallel sensory periods[23] of movement and language. There is no connection between being an early crawler or walker and having an early developed language proficiency. On the contrary, children who very early on start making "mmmm-sounds" and are able to say "mum" already around the age of six months, often proceed more slowly in regard to their motor skill. It almost appears as a child cannot use the same energy to develop simultaneously in different areas of development. Of course, this is only a hypothesis that would require further observations and studies. However, in the case of Sandro and Dino, this was the case. One thing that is certain is that every child has their own pace of development and that the claim of "development leaps" – which in fact disavows it – often ends up creating insecurities that might become permanent. The freedom to move, without being restricted by material things like fences or high chairs is in direct correlation with good posture and healthy muscular development.

"Every useless help is an obstacle to the child's development"

Adele Costa Gnocchi always recommended her pupils to adhere to Maria Montessori's idea that the educator should continuously observe what task the children are able to do themselves; take a biscuit out of a box; put the spoon in the pot; put on the sock on their own feet etc. When the children do these things by themselves the educator should only facilitate, wait patiently and encourage the child without pushing them. By doing this, the child will develop a straight posture and fluency in their movements that will have a direct influence on their mental and emotional developments. When all the aid is as indirect as possible the result is that the child develops a sense of inner calm and self-confidence. The sensitive period in the development of language also requires adequate attention. A problem that has emerged during the last ten years or so is that children are cared for by a larger number of different people, even from the first months of their lives. In other words, the children, from a very young age, will meet different babysitters – who all come from different backgrounds – and at the daycare, the educators rotate during the day in a way that resembles a pediatric ward. What effect does this have on the children? According to my observations, the initial period between mother

and child – that spontaneous dialogue that creates such a strong bond between them and is so vital in the future development of the child – has gone missing. And all the different people that pass in and out of the young child's life are not interested in the child – illustrated in the way they communicate with them – in the same way as a mother or if just one educator was entrusted with the care of the child. This phenomenon is not new, and it is related to larger societal changes in the job market. However, a constantly changing vocal landscape prevent children from absorbing the sounds of a language in a certain way. Of course, the children adapt themselves to this, given the fact that their internal thrust of verbal absorption is very strong. However, this still results in a sense of uncertainty, a poorer vocabulary, language delays, and an extremely approximate syntax. All of these negative side effects can be seen when the children reach school level. These issues should be placed at the center of attention amongst the daycare that is opened for children between the age of zero and three. Therefore, the development of a well-articulated language that is rich in its nuances is another important pillar in the well-being of the individual and for their ability to communicate.

Recognizing the sensitive period of order

Since 1947, we have been working hard to find out how to best satisfy the children's need for activity. At the same time, as we were looking for that answer we have also observed how children reject any sudden change when it comes to people or the environment. This indicates that there is a sensitive period in a child's development related to order and stability. Montessori first described this sensitive period in her book Il Bambino in Famiglia (1936),[24] a masterpiece not sufficiently appreciated compared to her other books, even in the Montessori community. For us at the AIM, during the end of the war and with the lack of other books on the topic, this book functioned as an invaluable guide. In this book, Montessori describes, amongst other things, how a child at the age of one starts to cry when the mother takes off her cloak and then calms down when she puts it on again; the child that is looking at some sand on the floor begins to cry when it is swept up; and the child that start to cry when their bathing routine is changed. In the same book, Montessori writes that this is an unconscious instinct that begins to manifest itself during the child's first year and reaches its peak around the age of two: the child needs to build his own mind, to see that things are always in the same place and always used as it always has been. Often in our lives, we are forced to adapt to sudden changes and these changes have a big effect on all of us. However, for children that are in this sensitive period, these changes become a great disturbance. It is therefore important to be attentive that children at this age react strongly to these changes. This is of vital importance if we do not want to hurt our children.

To give some examples: Mira, 12 months, sees her father enter the room with a new broom that he has just bought at the market. The father puts the broom against the bed and greets his daughter affectionately, but she burst into tears and rejects his greeting saying: "Potto, potto". When Mira's father removes the broom from the room she becomes calm and reassured, she smiles at her dad and embraces him happily. It becomes clear that at a certain age this reaction is biological and cannot be solved by reasoning. These changes are simple instinctive and unacceptable to the children at this age.

When I was working at the Scuoletta, I had prepared two aprons with different colors, one in green and the other in one pink but both had the same flower pattern. The first day that I wore the apron in a different color, the younger children looked at me with a strange expression, almost as if they did not recognize me. One of the older boys told me to throw it away because it was ugly. I will never forget this incident, in my opinion, it is therefore of great importance that educators that are working with children aged between 0 and 3 are aware of the sensitive periods of children and value the children's need for continuity. This is achieved by minimizing changes and the changes that are needed to be made should be introduced slowly and in small doses, giving the child time to accept the new situation without feeling lost or abandoned. Children are both conservative and curious at the same time, so it is important that children are not rushed, which they are often nowadays.

A friend told me about her 18-month old nephew who always had difficulties to sleep during the first night when they went on holidays. He cried and was restless. The parents brought him to their bed and consoled him, but when he woke up later he looked at his parents as if he did not recognize them. In the end, he solved the problem himself by taking his pillow into the shower cabin – almost similar to the shower cabin at home – and fell asleep there.

Sensitive of changes from the first days of life

This phenomenon became more relevant when I began to observe similar reactions amongst children of a very early age. The protest of newborns was almost always related to the rejection of the mother's breast, as in the

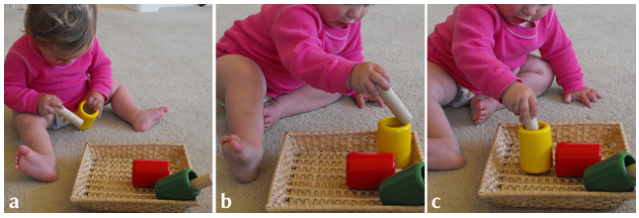
following cases: Bruno, eight days old, despite being hungry did not want to breastfeed and cried instead. Maybe the mother had used a different scent after her shower? To test this hypothesis the mother took a new shower and immediately afterwards Bruno took the breast. Clara, ten days old, refused to breastfeed because her mother had just put on nail polish, after removing the nail polish and carefully washing her hands Clara, took the breast. Anna, six days old, had just arrived home from the maternity ward and had just breastfed. Anna looked tired and sleepy so her mother puts her in the cradle and in order to get her to sleep raised a blue hood over the cradle. Anna began to cry when the blue hood was raised, we later understood that she was used to the white hood of the clinic and reacted strongly to the change to a darker hood. At the AIM we have documented many observations that are related to children reactions to what appears to be minimal changes. When I read the observations by Françoise Dolto, who had tried to console many newborns who did not have any family members near them at the hospital, by putting something the mother had worn in their beds, or, Aidan MacFarlane's research on newborns' ability to recognize the smell of their mother's breast, I got further confirmation of the hypothesis. It emphasized that newborns are very delicate and need the maximum possible amount of stability. The argument often raised against this is the sentiment that it is better for the children to get used to change from the beginning. However, according to our experiences, small children cannot "get used to" the stress caused by sudden changes. For the sake of their well-being, they need stability. At an older age, however, changes become more acceptable – within certain limits – and even interesting for the child. If one is able to adhere to these needs of the child – simply by upholding the status quo as much as possible – the child will develop "a secure base"[25] built on trust and mutual understanding.

If a child is later separated from the mother, the separation must be gradual. It is important that they are in the care of a stable educator that is active with regard to bodily care (food, sleep, washing and changing of diapers), those activities that most strongly remind the child of their mother. If children are left at the daycare for longer hours than a factory worker, without any attention to their vital needs, it greatly affects their "secure base". Therefore, the daycare must be organized to meet the needs of children and all this starts with the preparation by a well-prepared educator who has the ability to look at things from the children's point of view.

In our daycare, the children show great interest in the different variations of activities like putting things inside and outside (Figure 4a, b, c), to move from one vessel to another, to pour and fill; to empty with an instrument (hands or a spoon), transferring large seeds such as walnuts or corks or pieces of wood (if they still bring objects to the mouth), then corn flour, small seeds, and sand. Each material is separated from the others with suitable containers that the child can easily transport to the place the child prefers. As an example, a teacher followed eight children in a daycare called "Percorsi per Crescere" in Calcinate del Pesce (Varese) and she said: "I had prepared an insert activity: a box with some colored sticks to be inserted into a perforated tablet, and what did they do? They put them in the holes in the lid of the aquarium of the water turtles, which we have in the hall. I put them back in the right place again but some of them put them there again. What do you do? I let them do it. At the end of the day, I let the children bring them back to the box so they could do it again the next day. This happened. After a while, they stopped doing this" and she continued: "We got a little wooden, very stylized, pickup truck, and the children immediately understood what it was. Fifteen months old Renato. wanted to get a bean from the rack and put in on the truck. After a little while, sixteen months old Tiziana collected a bean from the ground and also put it on the truck next to the other bean and for a long period they played together moving the car and the truck back and forth, alternating – which amazed me – and without saying a word, since they have very few".

Figure 4

Putting things inside and outside. Photo by Karin Slabaugh.



It is very important to validate what seems to be apparently insignificant childish actions because these seemingly childish actions are in fact a prelude to more complex activities. Even the smallest children get bored sometimes. It is said that children during their first year become unbearable as soon as they reach the upright position. This is because they are prevented from exploring the objects they find in the house. This obstruction makes the child feel disappointment and concern because their initiatives are not understood by the adults. This situation makes the child feel irritated and insecure and these

feelings manifest themselves through tears, aggressive gestures, and difficulties to concentrate, which are very difficult to mend. Often the children are "drugged" with pacifiers and lose their curiosity and independence. So, this is a very important reflection.

Based on my continuous and long observation conducted at the AIM, the importance of activating the child becomes evident. But when should one begin to activate the child? The answer is right from birth, from the first sensory discoveries and gradually with more complex actions. This is evident to everyone who has observed this. From the gestures of looking at each other's hands and the first active movement of the fingers at the age of about four months to put some balls in and out of a box at the age of fourteen months, are all signs of the same thing – to discover the function and fabric of things.

Conclusion

The present text is the report of findings that have come about in the course of around sixty years of work, starting from observations and care in childbirth, newborns in the family and at the clinic, children in their first months of life and in the early years – work and guidance in daycare and nursery as well as adult education in Montessori courses. Further experiences have been made by me together with a group of men and women gathered in the association "Percorsi per Crescere" in the city of Varese. In the wake of Montessori and Costa Gnocchi, we have followed the approach more scientific than philosophical – of observing before acting, of intervening as little as possible, looking at every human being as unique and unrepeatable, full of personal resources, each time different.

In short, the aspects – which we constantly find out about human development in the first three years and which are generally completely ignored – are:

- Choice of the object with the mouth, ears, eyes, before they can do it with their hands.
- Spontaneous repetition of each action.
- At the same time a strong concentration, a very precocious phenomenon inborn and not a consequence of subsequent learning.
- Extreme need, from birth, of a continuity and stability of sensory experiences.
- Great creativity in exploratory research in the phase of approximately around 12–30 months of age.

Behavior never valued before, it seemed to us as the alphabet of human activities is those that can make men and women responsible for the welfare of the planet. Because in this respect Montessori has defined the humans as cosmic agents, the question is: when does it start? Our answer is, on the basis of what has been described here, there is a period of preparation for individual and social development from an early age.

Notes

1. For further reading about the work of Costa Gnocchi see Honegger Fresco (2001, 2018).
2. Il CNM is still active with its head office at via A. Burri 39, 00173 Roma, segreteria@centronascitamontessori.it. It administrates some Roman daycare and directs the 0–6 training.
3. Mario Montessori Sr. served as Honorary President of the CNM and the senator and pedagogue Salvatore Valitutti was selected as the center's first president. Elena Gianini Belotti, who would later write the seminal book Dalla parte delle bambine (2013), was the first director of the center.
4. Daycare is a translation from the Italian word "Nido".
5. Commonly referred to as the Geometric Cabinet, and historically called Geometric Insets in Wood, or Cabinet of Wooden Insets and Frames (translator's footnote).
6. Quaderno Montessori (2011), p.6.
7. All the names of children are invented by the author and do not correspond to the children's real names.
8. Montessori was inspired by the term from Blaise Pascal, (French philosopher and mathematician from 1600), who had explored the l'*esprit geometric*. The term was based on his own observations, that the human mind from the early years has a logical-mathematical ability.
9. The modality of learning which I had experienced and experimented several times in CEMEA (Centri di Esercitazione ai Metodi dell'Educazione Attiva) organized by the Florentine group from 1954 to the nineties, is an excellent example of freedom, creativity and group life.
10. L'ONMI (Opera Nazionale Maternità Infanzia) The ONMI (National Childhood Maternity Work) fascist organization, in aid of the "popular class", a survivor of the war, for which the care of children 0–3 years concerned exclusively the sanitary sector.
11. Now called the ONLUS Cooperative.
12. Daycare in Sondrio, Vergiate, Gallarate, Varese città, Busto Arsizio, Germignaga, Cassano Magnago,

Legnano, Sondrio, Cardano al Campo, Campagnola a Bergamo and other places.

13. For further reading see Elinor Goldschmied & Peter Elfer (2012); Elinor Goldschmied & Sonia Jackson, (2004).
14. For further information see Anita M. Hughes (2010).
15. Emmi Pikler's observations are spread through her books in Hungarian, German, Russian, French, Italian, English, etc; the effective paintings made by Klara Pap and numerous videos in Budapest. For further reading see David Myriam & Appell Geneviève (2008); Emmi Pikler (1968); Emmi Pikler, (1979).
16. Lòczy ou le maternage insolite was the title of the book by Myriam David and Geneviève Appell who in 1973 for the Emme Editions made known in Italy that extraordinary pedagogical experience, hitherto hidden by "the Iron Curtain". See David Myriam & Appell Geneviève (2008).
17. The commercial games do not respect, for obvious market reasons, any taxonomy. They are usually made of plastic and have multiple entry holes with various geometric shapes. Also in the material for the little ones for which the constant principle of all the sensory material should be kept in mind: the isolation of quality. In this case one difficulty at a time rather than various together from the beginning.
18. The "nido" does not exist today. See "Il Quaderno Montessori" A. XXVII, n.107, (2010).
19. "Man the maker".
20. See Giacomo Rizzolatti on mirror neurons and the research by Barbara Rogoff (1993, 2001) about how small children learn together with caregivers and
21. "*watered down*", was an ironic comment from Vincenza Fretta, a Montessori friend from New York.
22. In Italian *L'Autoeducazione* (1916).
23. Sensitive periods have long been identified in many animal species. Montessori was the first to discover its existence in human beings. This merit was recognized by one of the most distinguished ethologists of the twentieth century, the already mentioned Eibl-Eibesfeldt (1975).
24. The book already appeared in Vienna in 1923 as *Das Kind in der Familie* the English edition, The child in the family (1989b).
25. A concept from John Bowlby, ethologist, psychoanalyst, and the founder of the theory of attachment. See Van der Horst, Frank (2011).

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Competing Interests

This manuscript has been peer-reviewed externally and the process was anonymous. The final decision was made by the Editor in Chief.

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Variation Theory and Montessori Education

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Keywords: *Arithmetic, Didactics, Geometry, Isolation of qualities, Montessori education, Montessori material, Variation, Invariance, Variation theory*

Abstract: In this article we examine the relation between variation theory and Maria Montessori's didactic theory. Montessori believed that training and sharpening of the child's senses are crucial for their continued learning; she therefore developed specific sensorial materials to be used in Montessori preschools for such a purpose. As noted by interpreters of Montessori education, a key principle in this material, as well as in variation theory, is the use of variation and invariance. However, in this article, lessons in two different areas than the training of the senses are analysed from a variation-theoretical perspective on learning; these lessons originate from Montessori's own writings and from extracts from Montessori training courses. The result shows that a systematic use of variation and invariance can be seen as a more fundamental part of Montessori's didactic theory and is not only applied in the sensorial training. The article will offer theoretical concepts useful when explaining why lessons in various areas should be presented in the way they are described.

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Introduction

Montessori education is spread all over the world and the number of schools is constantly increasing (Ahlquist, Gustafsson & Gynther, 2011). Regardless of the part of the world or country the school is located in, visitors to Montessori schools will enter classrooms whose design is very similar. That is because the physical environment with its didactic[1] material is clearly described by Maria Montessori (e.g. Montessori, 1912; Montessori, 1914/65). Unlike the practical application, however, some interpreters of the pedagogy have noted that its theory is vaguely described in Montessori's own literature (e.g. Feez, 2007; Lillard, 2005; Montessori Jr., 1976/92). Feez (2007), for example, claims that Montessori only left behind what could be considered a practical application of the pedagogy rather than a theory.

However, a key principle in the application of the pedagogy, which has been noted by interpreters at a more theoretical level in recent years, is the use of variation and invariance (or contrast and sameness) within the training of the senses practised in Montessori preschools (e.g. Marton, 2006; Marton, 2015; Marton & Signert, 2008; Signert, 2012). Montessori believes that this training and sharpening of the child's senses is of great importance and even crucial for the child's continued learning since it will enlarge the field of perception and consequently offer a more solid foundation for intellectual growth (Montessori, 1948/93). This sensorial training, however, must be practised according to a certain principle in order to provide the right foundation for intellectual growth. Montessori describes it in the following words:

> *In the ordinary schools of today, teachers often give what are called 'object lessons' in which the child has to enumerate the various qualities of a given object: for example, its colour, form, texture, etc. But the number of different objects in the world is infinite, while the qualities they possess are limited. These qualities are therefore like the letters of the alphabet which can make up an indefinite numbers of words. If we present the children with objects exhibiting each of these qualities separately, this is like giving them an alphabet for their explorations, a key to the doors of knowledge. Anyone who has beheld not only the qualities of things classified in an orderly way, but also the gradations of each, is able to ready everything that their environment and the world of nature contains. (Montessori, 1949/82, p. 159)*

Montessori's idea (1949/82) is to present didactic materials that demonstrate a distinct contrast between objects so that the differences between them are made obvious to the child. This will make the child curious and interested in exploring them. One of the didactic tasks of education is therefore to grade a series of objects which have to be identical with the exception of one single quality that has to vary. Consequently, the material is designed in order to help the child discriminate and classify among different sensorial aspects. One example of such material is the set of bells with which the child will distinguish and grade different tones. The bells are identical in appearance but differ with regularity in terms of tone. Consequently, what is common to all sensorial materials is that it is only the investigated quality that distinguishes two objects of a particular material from each other. In regard to other qualities, the materials are identical. Other sensorial materials designed in this way are, for example, the Brown prisms, all of which have the same length but differ only in the degree of thickness, whereby the child will learn to distinguish the thickest or the thinnest. The Red Rods, all have the same thickness but differ in length. The Cylinder blocks can be ordered by height by the child to distinguish tall from short, and with the Colour tablets the child will grade nuances of colour in order to distinguish between the darkest and the lightest. According to Montessori (1914/65), this contributes to the development of the child's language skills so that the child will be able to use their language in a more exact way. Children will be able to describe their experiences, for instance that a line is thin and not small (ibid.).

Montessori (1914/65) believes that her theory will have implications in the long term, as it develops the child's ability to recognize, observe, reason, judge and use the "power of discrimination". This is an important "psychic acquisition", which will retain their learning abilities. If the teacher prepares the objects of learning in an orderly way, the children's minds will enter "the Creation instead of the Chaos" (p. 130–131). Montessori (ibid.) gives a number of metaphorical illustrations to clarify what her didactic theory will accomplish, for example by exemplifying the difference between the scientist and a person without knowledge looking through the same microscope. The scientist will discover details which are impossible for an untrained person to see, which is also true of the astronomer who will see things clearly through a telescope compared with someone not familiar with that scientific field. Montessori

also compares a botanist and a visitor walking through a garden.

The same plants surround the botanist and the ordinary wayfarer, but the botanist sees in every plant those qualities which are classified in his mind and assigns to each plant its own place in the natural orders, giving it its exact name. It is this capacity for recognizing a plant in a complex order of classification which distinguishes the botanist from the ordinary gardener, and it is *exact* and scientific language which characterizes the trained observer. (Montessori, 1914/65, p. 130)

The aim of this article, however, is to explore, analyze and report on the validity of variation and invariance in other areas (and consequently other materials) than the training of the senses. The question we raise is whether the application of variation and invariance is valid in other areas as well and could therefore be seen as a fundamental idea in Montessori's view of learning that has not been noted so far. If so, a variation-theoretical perspective on learning could be seen as an important part of Montessori's didactic theory in general, thereby offering one answer to the question why lessons should be presented in the way described.

In the next section, we will initially describe some key concepts in variation theory. This section is followed by a description of the way in which teaching in Montessori education is implemented within two chosen areas at an elementary level. These descriptions are followed by analyses of the ways in which each description is related to a variation-theoretical perspective on learning. The article ends with a discussion of the results and their practical implications.

Learning to see in order to learn to do - a variation-theoretical perspective

According to Marton (2015), a distinction can be made between two ways of learning in school.

> *One way is to make the object of learning (that which is to be learned) your own, to discern the important aspects of the content of learning and the relations between them. The other way is to learn what to do and say in order to meet the demands imposed upon the learner by the teacher or the test. (p. 14)*

If the latter kind of learning is stressed, less of the first kind might happen. Hence the teacher should above all create conditions which will allow the students to acquire the necessary aspects of the object of learning and the relationships between them. In that case, students will learn how to do things by seeing how things are related to each other, rather than just learn a certain order as told by the teacher. This is significant for a variation-theoretical perspective on learning which indicates that "mastering an educational objective amounts to discerning and taking into consideration its necessary aspects" (ibid., p. 23). Thus in a variation-theoretical perspective learning is seen as "learning to see" (ibid., p. 36). According to Montessori (1914/65), this is precisely what working with the sensorial materials seeks to establish within the child. As Montessori points out:

> *The child then has not only developed in himself special qualities of observation and of judgement, but the objects which he observes may be said to go into their place, according to the order established in his mind, and they are placed under the appropriate name in an exact classification. (Montessori, 1914/65, p. 129)*

When learning is seen as "learning to see", it follows that someone has learnt something when he/she is aware of other or more aspects of a phenomenon than before (Marton & Booth, 1997). Learning is therefore "mostly a matter of reconstituting the already constituted world" (ibid., p. 139). However, when we experience a phenomenon, we often find it unclear, so "the whole needs to be made more distinct, and the parts need to be found and then fitted into place, like a jigsaw puzzle that sits on the table half-finished, inviting the passerby to discover more of the picture" (ibid., p. 180). What Marton and Booth say here is that the relationship between what can be seen as the whole and its parts must be visualized if learning is to be made possible. As Lo (2012) argues: "There must be a whole to which the parts belong before the parts can make sense to us. We cannot learn mere details without knowing what they are details of. When the whole does not exist, learning will not be successful" (p. 26). This is also pointed out by Montessori, who formulates it as follows: "to teach details is to bring confusion; to establish the relationship between things is to bring knowledge" (Montessori, 1948/96, p. 58). Montessori also points out the importance of classification, for example when a child is about to study living beings. Classification of animals then gives the child a picture of the great number of

animals as well as their diversity. This will help the child to distinguish between the different groups of animals and from there go into details (ibid.). If the learner has not seen a specific necessary aspect or part in relation to what can be seen as the whole, and therefore not made the object of learning her own, it is, according to variation theory, seen as "critical" (Lo, 2012; Marton, 2015). This means that it has to be discerned by the learner in order to meet the educational objective. The teacher's ability to help the learner to do this will, of course, be facilitated if the teacher is aware of the critical aspects of a certain learning object and is thereby able to direct the learner's view towards such aspects. Montessori is critical of traditional[2] education where the teacher talks and the child remains passive. According to Montessori, the child does not learn by just listening to words; the child has to make discoveries. To consider mind and movement as separate from higher functions is one of our times "greatest mistakes", states Montessori (1949/73, p. 140). Instead, Montessori regards mind and body as one entity. This kind of standpoint implies a different school environment, organized with materials that allow children to make their own discoveries (Ahlquist, 2012). In Montessori education, the Montessori materials serve such a purpose. This does not mean leaving children alone while working with the material. The teacher's responsibility is to observe the children's work without interfering, letting them instead work at their own pace, supporting them when needed and challenging them by discussing and examining their discoveries and letting them express their understanding.

Variation and invariation

According to variation theory, the learner has to be aware of the difference between at least two features in order to discern them. Marton (2015) gives as an example that a prerequisite for the inhabitants of an entirely green world to be aware of its "greenness" is that they are exposed to a different colour as well. As Marton argues "You cannot start with two green things and thus be become aware of the colour green. Nor can you understand what truth is by inspecting true statements only" (ibid., p. 48). Rather, learners have to discern what green is at the same time as they discern what is not green. This is, of course, possible only if green is exposed in contrast to a different colour. However, this is not enough. In addition to being exposed to varied colours so that they will be contrasted with each other, other aspects like shape and size have to be kept invariant in order to make it likely that the aspect in focus (colour) will be discerned.

Generalization and fusion

Once the learner has found the meaning by contrast, he/she has to generalize the aspect which has previously been separated. If the aspect, for instance, is colour, generalization is achieved by keeping the colour invariant but varying other aspects such as form and size. The aim of generalization is not to find out what different aspects have in common; rather, it is to find out how different aspects vary. If the aspect is colour, the conclusion we will draw through generalization will therefore be something like: "so this can be red, and this and this", rather than "they are all red". As Marton (2015) points out: "Through contrast, we are trying to find necessary aspects of the object of learning, those that define it. Through generalization, we want to separate the optional aspects from the necessary aspects" (p. 51). However, from a variation-theoretical perspective, it is important here to emphasize that such generalization should always be preceded by contrast (ibid.).

The final step is to let the learner experience simultaneous variation in all relevant aspects. In variation theory, this pattern of variation is called fusion: "it defines the relation between two (or more) aspects by means of their simultaneous variation" (Marton, 2015, p. 51). The learner will then experience simultaneous variation in all relevant aspects. In the case of colour, the learner will, for instance, experience that any colour might appear with any form.

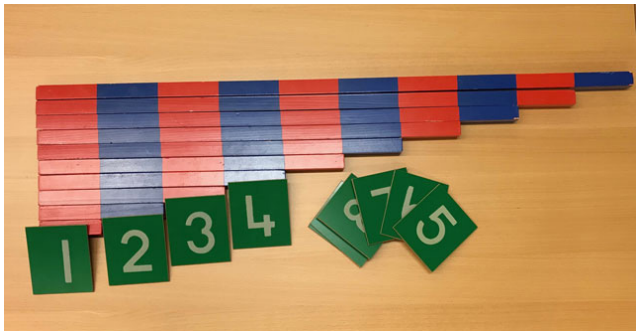
Variation theory in other areas than sensorial training

Initially, we stated that Montessori, as in variation theory, emphasized that the child will develop their ability to "see" in the work with the sensorial materials in preschools by using patterns of variation and invariance. We will now look into the ways in which certain other areas are dealt with according to Montessori at an elementary level and whether it can be assumed that Montessori designed the materials and the teaching with such a purpose in other areas as well. We have chosen to look into one specific area in teaching arithmetic and one in teaching geometry. We decided to choose these areas as they are either described in detail in Montessori's literature or in oral presentations within Montessori training.

Introducing numbers

When the teaching of numbers is introduced in Montessori education, teachers use a material called Number Rods, shown in Figure 1, which consists of ten rods of different lengths. The shortest is one decimetre long, the longest one metre, while the intervening rods are divided into sections one decimetre in length. These sections are coloured alternately red and blue.

Figure 1
The Number Rods. Photo by Eva-Maria T. Ahlqiuist.



In Montessori's description (1914/65) of how the material is supposed to be used by the teacher she writes:

> *When the rods have been placed in order of gradation, we teach the child the numbers: one, two, three, etc., by touching the rods in succession from the first up to ten. Then, to help him gain a clear idea of number, we proceed to the recognition of separate rods by means of the customary lesson in three periods. We lay the three first rods in front of the child, and pointing to them or taking them in the hand in turn, in order to show them to him we say: "This is one." "This is two". "This is three". We point out with the finger the divisions in each rod, counting them so as to make sure, "One, two: This is two." "One, two, three: This is three." Then we say to the child: "Give me two." "Give me one." Give me three." Finally, pointing to a rod, we say, "What is this?" The child answers, "Three," and we count together: "One, two, three." (1914/65, p. 170)*

When the children have worked with the rods for some time, the teacher will introduce the Sandpaper Numbers, which consists of a box with cards on which the numbers from one to nine are cut out in sandpaper. Montessori (1912/64) now states that the child is supposed to touch the numbers in the direction in which they are written and to name them at the same time. He/she is also shown how to place each figure upon the corresponding rod. After working with the rods and numbers, the teacher will introduce the Counting Boxes shown in Figure 2. This material consists of a box divided into ten compartments (0–9), on each of which the corresponding number is printed, and the child places the correct number of pegs in the compartments (Montessori, 1934).

Montessori also writes that another exercise associated with the child's work with the boxes is to put all the Sandpaper Numbers on the table and place the corresponding numbers of cubes, counters and the like below (ibid.).

Figure 2
The Counting Boxes. Photo by Eva-Maria T. Ahlqiuist.

The didactic material used for teaching the first arithmetical operations is the same one as used for numeration, the Number Rods. Montessori (1912/64) writes:

> *The first exercise consists in trying to put the shorter pieces together in such a way as to form tens /…/ In this way we make four rods equal to ten. There remains the five, but turning this upon its head (in the long sense), it passes from one end of the ten to the other, and thus makes clear the fact that two times five makes ten.*
>
> *These exercises are repeated and little by little the child is taught the more technical language; nine plus one equals ten, eight plus two equals ten, seven plus three equals ten, six plus four equals ten, and for the five, which remains, two times five equals ten. At last, if he can write, we teach the signs plus and equals and times /…/ When all this is well learned*

and has been put upon the paper with great pleasure by the children, we call their attention to the work which is done when the pieces grouped together to form tens are taken apart, and put back in their original positions. From the ten last formed we take away four and six remains; from the next, we take away three and seven remains; from the next, two and eight remains; from the last, we take away one and nine remains. Speaking of this properly we say, ten less four equals six; ten less three equals seven; ten less two equals eight; ten less one equals nine. In regard to the remaining five, it is the half of ten, and by cutting the long rod in two, that is dividing ten by two, we would have five; ten divided by two equals five. (p. 333–334)

Analysis of how numbers are introduced

Initially, we can note that the material presented above, in itself, isolates the quality "number" by its design. When the numbers 1, 2, 3… are introduced, it is only the numbers that vary. Other qualities in the material are identical. Furthermore, "one" is introduced in contrast to "two" and "three" and so on.

Another important aspect when it comes to the design of the lessons is the order in which these lessons are given. Looking at the sequences of the lessons, it seems clear that the purpose of such sequences is to make it possible for the child to initially find out the meaning of numbers by contrast and then, later, generalize the aspect which has previously been separated. This, for example, is done by working with different objects such as counters, cubes and the like. which the child matches with the Sandpaper numbers or the right compartment in the Counting boxes.

The importance of contrast is also evident when arithmetical operations are introduced with the Number Rods. In Montessori's description of how this should be done, it is noticeable that addition is introduced in contrast to subtraction and that multiplication is introduced in contrast to division. The contrast between addition and subtraction, for example, is made by first putting rods together and then, later on, taking them apart. In this way it is possible for the child to "see" the relationship between, for example, 3 + 2 = 5 and 5 – 2 = 3. When Montessori links addition and subtraction together in this way, the relationship when it comes to what can be seen as parts and wholes is stressed, which may make addition easier to grasp since it is introduced in contrast to subtraction.

When comparing the work with the Number Rods and the Counting boxes, it might seem at first sight as if the children in their work with Counting boxes repeat the same exercise as with the rods. However, we have to look at the way the Number Rods and the Counting boxes are designed. If we say that the number that each rod corresponds to can be seen as "solid", we then have to say that the pegs in the Counting boxes can be described as "loose". This corresponds to two critical aspects, the ordinal and cardinal property of numbers, which the child has to "see" in order to grasp the rules of arithmetic. Ordinal property means that each number refers to a place in an order (1st, 2nd, 3rd…). Cardinal property refers instead to the "manyness" of things (one book, two books…). Both aspects can be noticed in the way the work with the Number Rods and Counting boxes is designed, but each material stresses different aspects. When the children are working with the rods, they grab "the manyness", or as Montessori (1934) describes it, "one united whole", that the rod in itself represents in their hands, even if they will also be able to identify the ordinal property when, for example, counting each section of the rod. The same can be said about the work with the Counting boxes, but in this case the ordinal property is more prominent when counting each peg than in the work with the Number Rods, even if the main aim of the work is to match each compartment with the right number of objects.

What can be seen as an additional critical aspect when handling the Number Rods as described above is that numbers are wholes that can be divided into parts. This may be noticed by the child in the work with arithmetical operations. When a child, for example, tries to put rods together in such a way that they form tens, this will illustrate that wholes can be divided into parts. In this example, the work done by the child illustrates that ten can be split into nine and one and that they are parts of the whole ten and so forth.

Introducing triangles

Geometry is presented in preschool by providing children with sensorial experiences and presenting the names of the different geometrical objects. Montessori argues:

Observation of form cannot be unsuitable at this age; the plane of the table at which the child sits to eat his soup is probably a rectangle; the plate which contains the meat he likes is a circle; and we certainly do not consider that the child is too immature to look at the table and the plate. (1948/83, p. 165)

The geometry material in preschools consists of blue Geometric solids containing objects of ten different shapes, a Geometry Cabinet with thirty-six plane figures and Triangle boxes used to construct polygons. These materials are also utilized in elementary education. This is, in fact, something that is fundamental in the Montessori curriculum: materials from preschool build the basis for further studies at higher levels. "They [the materials] form a long sequential chain of learning: each material can be placed within a hierarchy in which the simplest one forms the basis for the next. Nothing is left to chance in this sequence, everything is provided…" (Tornar, 2007, p. 120).

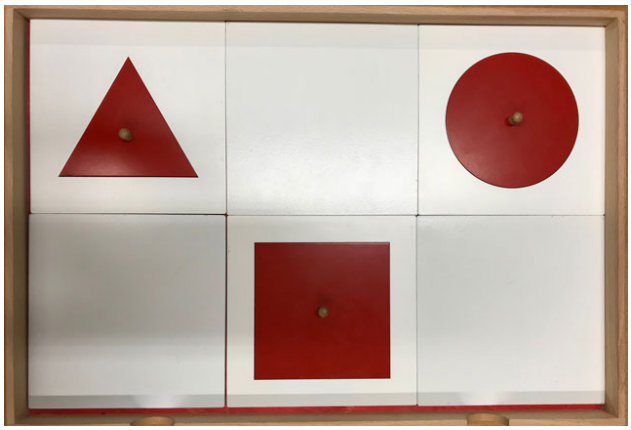
At an elementary level, there are more materials than mentioned above. Here, though, we will focus on the work with the Geometry Cabinet and how it is used to make it possible for the children to deepen their knowledge of triangles. The study of geometry in elementary classes is a work of experimentation and discoveries. Here we present extracts from the introductory notes to geometry from the AMI course in Bergamo:[3]

> *Montessori's psycho-geometry reveals the essential place that geometry holds in human development, both historically and now, in the educational system. Psycho-geometry seeks to show the geometry inherent in life: organic and inorganic nature.*
>
> *For example, inorganically: crystals, snow-flakes and organically: formation of flowers, molecules etc. Further, we look at the supra-nature, the work of humans in constructive architecturally and in other designs. Similarly, it can be seen that geometry is based upon the observable order of our world. Geometry, therefore, cannot be seen only in the abstract. One can study geometry by studying the historical evolution of humans and also by observing carefully the world in which we pass our daily lives./…/ Geometry, γεω; geo- "earth", μετρία -metron "measurement", the measurement of the Earth on which we live. This implies the relationship between humanity and the objects of our Earth, as well as knowledge of the relationship between these objects themselves. We study fundamental elementary Euclidian geometry./…/Our [the Montessori] geometry is made up of a) plane geometry, the study of the properties and relations of plane figures, and b) solid geometry, the study of figures in space, figures whose plane sections are the figures we have already studied in plane geometry.*

In this article we will focus on the work with the Geometry Cabinet and how it is presented so as to expand the children's knowledge of the different shapes. Here, we will concentrate on different types of triangles. At the elementary level, the geometry lessons, when adequate, will relate to the history of the subject area, and the etymology of words will be identified for each new concept the children meet. The study of triangles shown below will focus on the triangle examined by its side and by its angles and the work on uniting the sides and the angles.[4] The study of other plane figures is largely similar to the work with triangles.

The Geometry Cabinet consists of six drawers, each containing six wooden squares with geometric plane figures in the same colour[5] inserted in each square. On top of the cabinet there is a presentation tray shown in Figure 3, representing three of the geometric figures that will be found in the cabinet. The tray has six wooden squares, three of which contain an equilateral triangle, a square and a circle.

Figure 3
The presentation tray. Photo by Eva-Maria T. Ahlqiuist.

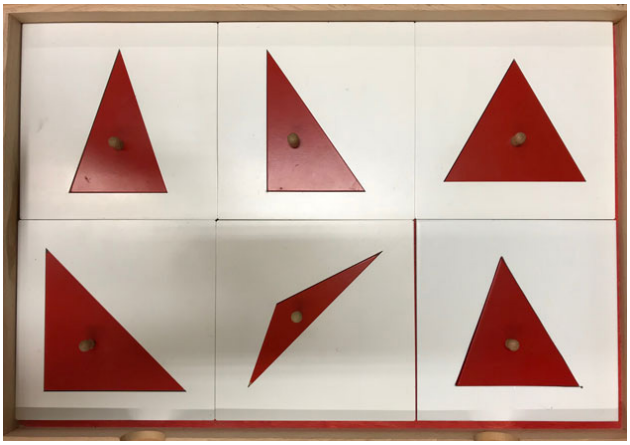


Each figure in the cabinet has a small handle in the centre, making it possible to lift up the figure when taking it out of the frame. The first drawer, shown in Figure 4, contains six triangles with the following shapes; an equilateral triangle, an acute-angled scalene triangle, an acute-angled isosceles triangle, an obtuse-angled isosceles triangle, a right-angled isosceles triangle and a right-angled scalene triangle.[6]

The second drawer has six rectangles, all with the same height, ten centimetres, and increasing from five centimetres in length to ten centimetres (the last one representing a square). The third drawer has six circles where the diameter increases from five to ten centimetres.

The fourth drawer has regular polygons from a pentagon to a decagon and the fifth drawer has other quadrilaterals, such as an irregular quadrilateral,[7] trapezium,[8] an isosceles trapezium, a kite,[9] a parallelogram and a rhombus. The last drawer has five[10] curvilinear figures, two kinds of quatrefoils, a curvilinear triangle,[11] an oval and an ellipse and also an extra triangle (an obtuse-angled scalene triangle).

Figure 4
The first drawer. Photo by Eva-Maria T. Ahlqiuist.



The children should be familiar with the name triangle and the etymological origin and be asked to pick out the triangle among other polygons from the cabinet and identify triangles by going out in nature or visiting the city.[12] Subsequently, the teacher introduces different types of triangles in the first drawer of the cabinet. First, the three triangles on the upper row are examined by its sides. The teacher presents the scalene and the isosceles triangle by having the two triangles stand in an upright position on the base, the scalene with "limping" legs and the isosceles with a pair of legs of equal length. Then these two triangles are compared with the equilateral triangle, whose sides are of equal length. The children can observe this by rotating the triangle in its frame. Then there will be a repetition of the names used, performed as what Montessori (1912/64, 1914/65) calls a three-period lesson. This means that after the teacher has given the presentation above, he/she checks if the children are able to recognize the different types of sides; and finally, the children confirm their understanding by naming and describing each triangle.

The next step is to examine the angles of the triangles placed on the bottom of the drawer, starting with the right-angled triangle, with the right angle as a base letting one of the legs follow the base and the other pointing upwards. The children compare this right angle with the angle between the floor and the wall in the classroom. The teacher tells the children the name of the angle. The next triangle explored is the scalene. The teacher asks the child to compare the scalene angle with the right angle in order to discover the difference. The children will then be asked to compare the obtuse angle with the acute angle by letting the child touch both of them. Then the teacher asks the children to examine all three angles of the acute-angled triangle, discovering that all angles are acute. The same procedure is done with the right-angled and the obtuse-angled triangle.

The third step is to unite the sides and angles. The teacher asks the child to write labels with the names of the sides and labels with the names of the angles of all six triangles. Each triangle will have two labels. Then the children are asked to tear off the word triangle from the labels and then unite the words of the angles (for instance, acute-angled) and the words of the sides (for instance, scalene). Finally adding the labels on which the word triangle is written (here exemplified by the acute-angled scalene triangle). There is then a discussion about the equilateral triangle: Should the triangle be called equilateral triangle or "equiangular" triangle? The children are asked to look for the name commonly used and will choose the name equilateral. The labels are rewritten on an undivided label for each triangle.

The children now order the triangles by constructing a coordinate system with two axes. On one of the axes the children put the word Angles written on a label, and below three labels with the names of the angles. On the other axes, the children put the word Sides, and below the names relating to the sides. The coordinate system will in this way have nine spaces, and the child is asked to put the triangles in their right positions. When this is done, there will be three empty spaces. The children now have to explore if there are triangles missing which could be placed in the coordinate system. By constructing triangles with help from The Box of Sticks[13] shown in Figure 5, they will discover that there should be an obtuse-angled scalene triangle (which can be found in the last drawer of the cabinet), but it is not possible to construct a right-angled equilateral triangle or an obtuse-angled equilateral triangle.

Analysis of how triangles are introduced

Montessori argues that the child has to have embodied experiences in order to distinguish different

Figure 5
The Box of Sticks. Photo by Eva-Maria T. Ahlqiuist.

shapes and she criticizes the traditional way of teaching as it does not help the child to recognize and remember the shapes.

> *The teacher draws a triangle on the blackboard and then erases it; it was a momentary vision represented as an abstraction; those children have never held a concrete triangle in their hands; they have to remember, by an effort, a contour around which abstract geometrical calculations will presently gather thickly; such figure will never achieve anything within them; it will not be felt, combined with others, it will never be an inspiration. (Montessori, 1917, p. 270)*

Montessori education combines movement and language. This is an essential feature of Montessori's didactic concept since manipulating an object facilitates the possibility to isolate the quality of the object in question. When starting by examining the different triangles, the fundamental condition is that the child already knows what characterizes a triangle. This was done with the presentation tray, where the triangle was initially contrasted with the square and the circle. What varies is the shape since the colour is invariant. In accordance with variation theory, the foundation of meaning here is the difference in shape. If instead the teacher had picked out three triangles of different colours, one blue, one red and one green, and told the child that all of them are triangles, the child would have had difficulty in grasping what a triangle is because there were no alternatives to a triangle. And even if there had been different geometrical shapes, but all of different sizes and in different bright colours, it would, according to variation theory, have been problematic for the child to focus on the essential aspect. As Feez (2008) states, the Montessori materials might seem to be old-fashioned in comparison with materials designed today, which often (p. 209) "interweave elements of educational knowledge with fantasy, popular culture and child-oriented imagery". But in accordance with Montessori education, the materials are learning-oriented as there are no distractions from what is to be focused on. When the child can distinguish the triangle among the other shapes in the presentation tray, a generalization is made by identifying a variety of triangles as triangles, regardless of their size, colour, rotational orientation or type. In the latter case, the child will not only discern the three corners of the triangle in order to recognize it as a triangle but now he/she also has to learn to discern the characteristics which are not necessary aspects of the learning object (such as size, orientation and so on). This order of sequence, in accordance with what is emphasized in variation theory, means that generalization is preceded by contrast. The next step is to examine critical aspects of the triangles: the sides and the angles. Examining the sides is made by contrasting the scalene triangle with the isocline and so on. The child does this by holding the triangles in his/her hand, which allows twisting and turning the different figures. This allows the child to internalize the shape, even when it is put in different positions. The same procedure is done by contrasting the angles. The child can insert the right-angled triangle in a corner and contrast it with an acute angle or an obtuse angle. By contrast, the child will be able to discern the necessary aspects of the object of learning. This again is followed by generalization, where the child has to identify either the different sides and in another exercise, identify angles among triangles that differ in many qualities. By this generalization the child is able to separate different aspects from the necessary aspects.

When the child is able to identify the sides of triangles and knows what characterizes their angles, the two qualities are united in one and the same triangle. This act can be seen as what Marton (2015) refers to as fusion. This exercise is done by organizing the different types of triangles as a pattern in a coordinate system. During this exercise, the child can use the Box of Sticks as an aid to construct the different triangles. As the lengths of the sticks differ in colour, the child will easily pick the correct length of the side of the triangle and by using a "guide angle" (a right angle) they will experience that every angle smaller than a right angle is acute, as well as that every angle larger than a right angle is obtuse. This work will help him or her to make certain observations, for example that all triangles have acute angles, but in order to be called an acute-angled triangle, all three angles have to be acute. They will also be able to realize that two types of angles, right and obtuse, can be combined by two types of sides, but the acute angle can be combined with all three types of sides. This exercise, which has been completed by fusion, where the child has combined and defined two critical aspects by a process of their simultaneous variation, makes it possible for the child to experience that there are only seven types of triangles.

Discussion

The activities within the areas described above are the result of Montessori's empirical research on how children learn. As shown in the analyses, the use of variation and invariance is to the fore in those activities. However, the latter is not made explicit by Montessori in her literature except for the sensorial training described in our introduction. In Montessori's (e.g. 1912/64, 1914/65, 1948/83) descriptions of the materials and their use, she mainly deals with the didactic questions 'what' and 'how' rather than explicitly expressing why the content should be treated in the way it is described. Cossentino (2009), who has examined Montessori teacher training courses, points out that this is also significant for the way the training is conducted by tradition and therefore sees it as a "transmission" of technique, rather than a development of an understanding of why the material should be handled in a certain way. When there is a lack of such competence, it is more likely that the presentation with the Montessori materials will be performed in an instrumental way. It is also reasonable to assume that the participants are poorly equipped for teaching in areas which have not been dealt with in their training. In a study conducted by Gynther (2016), one of the Montessori teachers did not know how to introduce the concept of proportionality as it had not been covered during her Montessori training. If she had understood Montessori's systematic use of variation and invariance as part of the didactic theory, it is reasonable to assume that she would have been able to clarify what is proportional, as well as what is not proportional when the concept was introduced to the children. The point we are making here is that Montessori training must not only make participants very familiar with the Montessori materials; it must also develop their awareness of the underlying theory in order to discern the why in the practical application and hence be prepared for the work to come. The theoretical concepts presented here will also function as a platform for teachers and others when reviewing the ways in which different topics are treated within various Montessori environments.

Our analyses show that the theory behind Montessori's didactic material, due to the design of the material and how the lessons should be given, is supported by variation theory, and we reveal that Montessori has clearly searched for and identified what in variation theory is referred to as critical aspects. Montessori's (1948/83) own observed lessons in which such identification is not done by the teacher further reinforces this result. Montessori describes, for example, a teacher who was asked to show how to present two plane figures, a square and a triangle, by teaching the child the shape of the figures. The teacher handed out the square and made the child touch the outlines while she said "This is one line, another, another, another; there are four, just count with your fingers how many there are. And the corners, count the corners, feel them with your finger, press on them, there are four of them too. Look at it carefully; it is the square" (ibid., p. 109–110). According to Montessori, the teacher was not presenting the shape of the square; she gave the children the idea of other concepts, sides, angles and numbers. Montessori states that this was an abstract lesson as a side or an angle cannot exist without relating to the whole figure, in this case the square, and in addition the child had to be able to count to four. Without knowing how to separate the shape of a square from another shape, and instead make a mathematic analysis, the lesson will only confuse the child. Montessori asserts that it is necessary that the teacher knows how to give a lesson. What she wants to make clear is that children can distinguish the shape of the figures by simply contrasting them.

What Montessori implies by replicating lessons like the one described here is that the critical aspects must be identified by the teacher if the necessary conditions

for learning are to be created. This is in accordance with Marton (2015), who declares that the design of the lesson must reflect "the ways of seeing something we are trying to help the students to develop" (p. 256), that is, what it is intended that the student should learn. Furthermore, such identification seems crucial if Montessori teachers are to be able to succeed in their efforts to observe and follow each child as the pedagogy advocates. Of course, this is because, if teachers are aware of the critical aspects of a learning object, it will be much easier for them to identify by observation if the intended object of learning has been reached, alternatively what aspect the learner is not yet able to discern. That being said, we want to make clear that although Montessori specifies aspects that must be considered, the teacher has to identify what is to be regarded as critical in *each* child's meeting with the learning object. What is regarded as critical could thus differ between children, which is why Montessori emphasizes the need for teachers to observe (Montessori, 1912/64, 1948/83, 1949/82) in order to be able to respond to children's expressed understanding as well as to challenge children's knowledge development.

As the use of variation and invariation is not always clearly expressed in Montessori's literature, even if the material and the sequences of lessons are described in detail, we believe that this article will have an impact on Montessori education. We also believe that it can contribute to variation theory with the idea that not merely seeing helps children to make knowledge their own. The fact that children are given the possibility to discover critical aspects by grasping them must be regarded as crucial. As Montessori (1934/2011) says, activities "involve the hand that moves, the eye that recognizes and the mind that judges" (p. 11). Viewing the body and the mind as interwoven (Ahlquist, 2012) in the explorative work accomplished by the children, as shown in the analyses above, supports the use of variation and invariation. With such an approach, the teacher should reasonably be able to assume that the object of learning has given the children an understanding and that the knowledge has become their own.

Notes

With regard to didactics we refer to the basic questions: *What* is it that should be taught and *how* should it be made available for the learner? These questions also include a "why": *Why* should something be taught and *why* should it be taught in a certain way? The *how* includes the learning resources, in this case the Montessori material, guided by the question: *Through what* do we learn? For further reading, see Liberg (2012) and Jank & Meyer (2018).

1. Traditional here refers to a way of teaching in which the children have few opportunities to make experiences of their own. Rather, what is to be taught is mainly "transmitted" to the child by the teacher (Granberg 2014).
2. Extracts from personal notes by Ahlquist from the AMI, Associazione International Montessori course, 1981–1982.
3. Here we concentrate on just one section of the study of triangles. The Montessori material in geometry consists of other materials, such as the Constructive Triangle Boxes, the Box of Stars, the Metal Insets and the Yellow Area Material.
4. Montessori suggested that the geometric figures should all be blue and the bottom of each tray should be yellow. Some manufacturers of the material made the geometric figures red and the bottom of the tray white.
5. The last of the seven types of triangles, the obtuse-angled scalene triangle, is found in the sixth drawer.
6. In American English, it represents a trapezium.
7. In American English, it represents a trapezoid.
8. This is a special kind of trapezium as there are two pairs of sides of equal length or all four sides of equal length but none of the sides are parallel. The drawer could also contain a boomerang, depending on the manufacturer.
9. Some manufacturers include a third quatrefoil (an epicycloid). In those cases, the drawer contains six curvilinear figures.
10. Also known as the Reuleaux triangle.
11. Examples of such work are given in Ahlquist, Gustafsson & Gynther (2018).
12. The Box of Sticks contains sticks from one unit to ten units, each unit in a different colour. Every stick has a hole in each end in order to be able to unify them with each other when constructing geometrical shapes. There are also neutral sticks with units from one to ten but of different lengths compared with the coloured sticks, as they represent irrational numbers. The material also consists of a set square, which is used to identify the angle as a right angle.

Competing Interests

This manuscript has been peer-reviewed externally and the process was anonymous. The final decision was made by the Associate Editor Christina Gustafsson.

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The Spread of Montessori Education in Mainland China

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Keywords: *Montessori, China, Localization, Early Childhood Education, Chinese Montessori*

Abstract: This paper is a historical account of the spread of Montessori education in mainland China. It surveys the general picture of early childhood education (ECE) in China and discusses the factors leading to the popularity of Montessori education in the 1990s. Although first introduced into China in the early 1900s, for reasons explained, Montessori education was unsuccessful in catching on as an education method in the early part of the 20th century. Following policy changes and growing interest in western education methods, Montessori education reemerged in the 1990s and has remained a sought-out education method since. In this paper, localization is also discussed as a prominent concern expressed in the Chinese research is ensuring Montessori education promotes and instills values consistent with Chinese society. As is shown, elements of the Montessori method are consistent with Chinese culture, creating a cooperative relationship between these two systems. Of equal importance, Montessori education emphasizes the cultivation of collective identity and societal relationships similar to Chinese culture, the slight difference between them being that Montessori also emphasized the construction of the individual as well.

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Introduction

If it were possible to sum up China's education history in one word, it would be *change* (Liu, 2010). This includes early childhood education (ECE), which has experienced frequent change since the first preschool opened in mainland China in 1903 (Feng, 2017). As a developing nation, China has routinely reevaluated ECE practices to keep up with research-based methods for educating its youngest citizens and ensuring methods suitable to the nation's cultural and social values. One such method used is the Montessori method.

The Montessori education method is the educational philosophy and method designed by Maria Montessori of Italy in 1907. It was first introduced in China over 100 years ago yet remained underdeveloped until the 1990s

and 2000s. This paper is a historical overview of Montessori education's development in mainland China and answers the following questions:

1. What is the historical account of the development of Montessori education in mainland China?
2. What circumstances influenced Montessori education's acceptance and spread in mainland China starting in the 1990s?
3. What are the concerns over the localization of Montessori education in mainland China in the 21st century?

Considering that China has the most Montessori preschools of any nation (Song, 2019; Whitescarver & Cossentino, 2008), information on its development and concerns surrounding it is of interest in sharing how Montessori education in China came to be.

The historical account in this paper "attempts to systematically recapture the complex nuances, the people, meanings, events, and even ideas of the past that have influenced and shaped the present" (Berg & Lune, 2012, p. 305). As discussed by Berg and Lune (2012), steps for conducting historical research have been followed to develop a narrative of the historical development and spread of Montessori education in China while connecting this development to localization. Localization is the process in which a concept or idea adapts to become suitable to the needs of the local culture, place, or time and is a repeated concern surrounding Montessori education in mainland China (Deng et al., 2016; Huo, 2001; Liu & Lin, 2003; Tian, 2007; Tian, 2008; Tian et al., 2014; Wang, 2012; Yang 2002, 2004).

The first section addresses Montessori education's arrival in China in the early 1900s, including the educational and national climate at the time. The second section describes the development of ECE in China post initial interest in Montessori education and develops the story of what led to the widespread acceptance and implementation of Montessori education in mainland China in the late 1990s and early 2000s. Lastly, concerns surrounding localization are discussed to explore Montessori education's applicability in mainland China in the 21st century.

Montessori Education's Arrival in China

The earliest published record on Montessori education in mainland China is from 1913 by Chinese scholar Zhi Hou (志厚). Zhi Hou was an educational scholar in the early 1900s, active in translating international education theories into Chinese for publication and introduction in mainland China. Zhi Hou's first article, titled "Ms. Montessori and her Teaching Method," praised Montessori's educational theory while describing her teaching instruments, theory, and classroom characteristics (Shi, 2012; Tian, 2007). In his article, Zhi Hou also expressed genuine respect for Montessori, which is evident in the title he gave to her. The original address Zhi Hou used in Chinese is 女史 (nv shi). This title contains the character female (女) and the character used to describe an important member of the king's advisory council (史). Upon reading this title, readers would instantly feel reverence and esteem for Montessori and her theories as the title bestowed her associated her with the intellectual advisers surrounding the emperor (personal communication, former Zhejiang University professor of education, Liu Hua, October 22, 2020).

Montessori education initially stirred great interest in mainland China, which resulted in over 20 articles published from 1913 to 1928 on Montessori education (Shi, 2012, 2015; Tian, 2007). Considering the national condition of China in the early 1900s, primarily rural and delayed in technological advances (Gu, 2014), and the cost and scarcity of publications (Tian, 2007), it is evident that Montessori education received a significant amount of resources and attention in the early years. These publications were written by bilingual scholars who had studied Montessori's writings in Italian, English, and Japanese and the handful of scholars who physically traveled to Italy to visit and observe Montessori's schools (Lau, 2017; Shi, 2012, 2015). Some of these publications even included pictures of Montessori classrooms and teaching apparatus, which was quite extraordinary considering the rarity of pictures at that time (Shi, 2012).

As early as 1914, one of the first institutions to research Montessori education in China, the Montessori Institute of Education, was established in Jiangsu Province (Liu & Lin, 2003; Shi, 2012, 2015; Wang, 2012). Specific purposes put forward by the institute included exploration of *sinicization* (中国化) and *localization* (本土化) of the Montessori method, as well as evaluation of the Montessori materials to see if it was possible to make them locally (Shi, 2015). Sinicization and localization are two terms used in China to address the process of adapting a concept or a method not originating in China to China's cultural, economic, social, and national context (Choy, 2017). As modern Chinese education scholar Gu Mingyuan (2014) describes, a critical function of education is to spread, select and transform culture, which only

naturally implies that an education system is evaluated and assessed for fit within a nation's culture, economy, and social values. Not only is assessing for fit important, but as Choy (2017) describes, it has remained critical to Chinese educators to recognize that western education practices are not to be taken as the standard for ECE, but as a reference point to adopting culturally sensitive and nationally appropriate methods. With localization and sinicization in mind, the Montessori Institute of Education sought to explore how to apply Montessori education within a Chinese construct to achieve contextualization.

According to the research conducted at the Montessori Institute of Education, educators and researchers quite early on developed a skeptical opinion toward Montessori education. One expressed reason for this skepticism is that researchers could not reproduce the Montessori materials, making Montessori education reliant on imported teaching materials (Duan, 2016; Lau, 2017; Shi, 2012, 2015). Reliance on imported teaching materials was an unrealistic expectation for China in the early 20th century. Jiang Menglin, secretary of the Ministry of Education in the 1930s, reflects this concern in his response to Montessori's invitation to send teachers to Rome for training:

> *Your materials are varied and expensive; it is not quite economical to utilize throughout our country. Chinese pedagogy focuses on designing educational materials that pertain to real-life living without the need to purchase teaching materials (translated from Lau, 2017, p. 66, 245).*

Seen as heavily dependent on expensive, imported materials, Montessori education was deemed incompatible for China in the early 20th century. Tagging onto the expense of Montessori materials, Chinese educators lacked sufficient knowledge of the method to implement Montessori education authentically, and there was also question surrounding how reading and writing should be taught according to Montessori principles, considering the difference between the Chinese language and Italian, or any other alphabet-based language system for that matter (Shi, 2012, 2015).

Another likely reason Montessori education experienced a decrease in acceptance in the early 1900s is in connection to educator William Kilpatrick's publicized criticism toward Montessori education (Kilpatrick, 1914). In 1914, Kilpatrick, a U.S. educator, wrote a critic of the Montessori method, questioning its claim as a scientific teaching method that negatively affected the method's acceptance throughout the world (AMS, 2020; Beck, 1961), including China (Shi, 2012, 2015; Wang, 2012). Adding to Kilpatrick's censure is the fact that influential Chinese educators of the early 1900s, namely Chen Heqin, Tao Xingzhi, and Jiang Mengxue, were all students of John Dewey at Columbia University in the United States (personal communication, former Zhejiang University professor of education, Liu Hua, October 22, 2020), as was Kilpatrick (Thayer-Bacon, 2012). Having learned Dewey's pragmatism theories, Chen Heqin, Tao Xingzhi, and Jiang Mengxue not only felt more proficient in Dewey's theories but probably also felt a degree of loyalty to Kilpatrick, with whom they undoubtedly interacted at Columbia University. Some, therefore, believe that Montessori education in China was not well received in the early 20th century, not only due to logistical concerns surrounding reproducing Montessori materials but also due to possible loyalty by leading educators at the time to the educational philosophies and teachers they had been exposed to at Columbia University, namely William Kilpatrick and John Dewey (personal communication, former Zhejiang University professor of education, Liu Hua, October 22, 2020).

By the late 1920s, Montessori education was practically non-existent in China and would remain in such a state for about fifty years when a new generation of educators would rediscover the method and reawaken its appeal to the Chinese nation.

The period of 1919 to 1978 in China saw a series of changes in sociopolitical ideologies that advertently also resulted in changes to the education system. Before discussing how Montessori education returned in popularity in mainland China in the 1990s, it is vital to understand the internal changes and challenges that took place within China in the 20th century as these historical circumstances influenced not only Montessori education's development in China, but ideologies, systems, and values of the Chinese education system in general.

Development of ECE in China

At the time of Zhi Hou's first article introducing Montessori education in 1913, ECE services had been in existence in China for around ten years (Zhu & Wang, 2005) and were strictly reserved for young children of elite families (Feng, 2017). This changed, however, in 1919, when China experienced both cultural and political reform as a result of an important event known as the *May 4 Movement*. The *May 4th Movement* led the nation to many reforms, including reforms in education, opening

educational opportunities to all social classes. The *May 4 Movement* also brought women into the workforce, increasing the need for childcare and educational opportunities for young children (Li et al., 2016).

To promote ECE accessibility and equality to all children following the *May 4th Movement*, Chinese educators labored to support working families by developing preschool programs within factories and near places of employment (Yang, 2017; Gu, 2014; Wang, 2012), making ECE services convenient and affordable (most programs were free) (Li et al., 2016). Simultaneously, educators developed preschool programs that had "'Chinese' characteristics" (Yang, 2017), meaning preschool programs supported, promoted, and reflected Chinese values and identity, as it had been seen that preschools previously were heavily concentrated with western culture and ideology instead of Chinese cultural values (Wang, 2012). Chen Heqin spearheaded ECE efforts, creating the slogan: "learn to be a person, learn to be Chinese, learn to be a modern Chinese person" (学做人，学做中国人，学做现代中国人), which means, one must learn the necessary skills to be independent ("be a person"), which includes teaching the elements of the culture ("be Chinese") that will lead the person to become a contemporary member of their community (be a modern Chinese person) (Wang, 2012).

Chen Heqin also developed an educational philosophy resembling Dewey's pragmatism theory called "living education," stressing the importance of active participation on behalf of the child in the education process. Quite different from traditional Chinese education that focused on the upholding and memorization of Confucius teachings (Gu, 2014), Chen Heqin emphasized the importance of instilling good habits, manners, and skills for independence as the main goals of ECE (Wang, 2012). Chen Heqin's theories eventually became the standard for ECE in China until the founding of the People's Republic of China (PRC) in 1949, which again brought about another dramatic change to China's education system altogether.

The founding of the PRC brought a series of transformations to the education system, including ECE, as Marxist educational ideologies were adopted throughout the whole education system, promoting the idea "that education[…cannot] separate from the development of politics, and the economy" (Gu, 2014, p. 178). This means that politics and the economy are involuntarily connected to education, as education is seen as the vehicle to promote and maintain the state's political agenda. As a new communistic government, China sought help from the Soviet Union with the hope that China could implement a similar education system promoting Marxism-Leninism beliefs (Zhu, 2009; Zhu & Wang, 2005) and that by doing this, China would progress politically and economically as a nation (Gu, 2014). With the help "of Russian ECE experts, the Ministry of Education drafted the *Kindergarten's Temporary Curriculum* (*Draft*) and *Kindergarten's Temporary Teaching Outline* (*Draft*)" which deemed the subject-based curriculum method *the* model for the country and banned all other ECE methods, including Montessori education (CNSECE, 2003).

Unfortunately, the Soviet Union's education system did not reflect developmentally appropriate teaching methods suitable for preschool-aged children. Where previously ECE reflected Chen Heqin's theories of "learning by doing" (Wang, 2012), educational methods under the PRC were subject-based, didactic, and made children passive in the education process (Zhu, 2009). Nevertheless, during this period, from 1949–1957, preschool education expanded and saw an increase in programs and teacher training institutions, all with support from the Soviet Union.

Following this period, from 1958–1977, China "went through a series of political turbulence, notably the 'Great Leap Forward' (1958–1960) and the 'Cultural Revolution' (1966–1977)" (Li et al., 2016), radically influencing the education system once again. Due to political instability, preschool programs and many other educational institutions were closed down, leaving many children without educational opportunities.

Following these two historical periods, ECE experienced another renaissance from 1978–1993, following China's move to a market economy, often referred to as the "opening up" (Choy, 2017; Qi & Melhuish, 2016), that led to a flood of western education philosophies and pedagogies into China. The spread and interest in western educational philosophies in China during the 1980s provided the appropriate conditions for Montessori education to reemergence in the 1990s and 2000s because, as a society, educators and parents were growing in awareness of developmentally appropriate education methods of which Montessori education offered.

In 1994, ECE received another setback when the central government cut off funding to ECE programs due to national budget cuts (Li et al., 2016; Zhou, 2011). Local governments at the provincial and city-level became responsible for funding public ECE programs, reducing public programs by a large margin. A dramatic decrease in public services took place from 1994 to 2009 as China adopted the policy of "Walking with Two Legs" (两条腿

走路), proposing that preschool education be supported not only by public initiatives but private organizations as well (Feng, 2017; Li et al., 2016).

From 2001 to 2007, the number of public preschool programs dropped dramatically from 60% of all preschools in China to 40%, creating a dominantly privatized preschool market (Zhou, 2011). In some areas of China, such as central and western China, the situation was much more difficult, as local and provincial governments in these areas could not provide sufficient funding to ECE programs. The total number of preschools fell nationally from 180,000 in the late 1990s to about 110,000 in 2000 (Feng, 2015) and continued to decrease until 2009 (Li et al., 2016).

It was against this backdrop that Montessori education resurfaced in China. After the shift to a market-based economy, Chinese parents and educators began exploring and adopting various western ECE philosophies, spearheading the way for Montessori education to return to mainland China (Fan et al., 2016; Hu & Szente, 2009).

The Reemergence of Montessori Education

The rediscovery of Montessori education in mainland China can be attributed to Beijing Normal University (BNU) professor Lu Leshan who started compiling information about Montessori education in the 1960s post her return to China from studying in Canada. After Lu's reintroduction of Montessori education, a new appreciation for the method transpired, leading to a dramatic increase in Montessori preschools, teacher training, and research (Lau, 2017; Yu, 1998).

BNU professor Lu Leshan is known in China as being the forerunner of the modern Montessori movement. In 1985 Lu published *Montessori Early Childhood Education* (蒙台梭利的幼儿教育), highlighting Montessori's education philosophy and rekindling interest in the method. Following Lu's footsteps, BNU professor Liang Zhishen founded the first experimental Montessori classrooms in 1994 in Beijing with support from the Montessori Education Research Foundation (MERF) of Taiwan and two donated sets of Montessori materials from Shan Weiyu of MERF. These were the first complete sets of Montessori materials in China, allowing teachers and researchers a better opportunity for understanding and studying the Montessori method (Lau, 2017).

Shortly after the cooperation between BNU and MERF, plans were announced to begin Montessori teacher training courses through BNU. In 1998 *Comparative Research Journal* published a one-page article titled, "'China Montessori Teacher Training Program' Launching Ceremony and 'Montessori Education in China' Seminar" (Yu, 1998). In this brief article, plans are shared concerning Montessori teacher training to begin at BNU in conjunction with support from the American Montessori Society (AMS). The article states the goals of the training as follows:

> *A considerable number of kindergartens in China have begun to use the Montessori education method[…]The problem of combining the Montessori education method with the national condition is of great importance. Society urgently needs an authoritative Montessori teacher-training program to teach, train, guide, and help [educators] improve the quality of Montessori education (Yu, 1998* translated*).*

In the late 1990s, with enthusiasm over Montessori education came the concern over how to combine Montessori education with the "national condition" of China. This concern is reminiscent of the early 1900s when Montessori education was first introduced to mainland China and educators were trying to discover how to institute it within a Chinese context. Yu (1998) states the solution rests in establishing an authoritative Montessori training program that would be authentically Montessori and characteristically Chinese. This would ensure culturally and nationally sensitive concerns would be addressed appropriately while remaining faithful to the Montessori method. Recognizing the need for assistance from a more developed organization, the AMS was singled out to help organize this effort due to the AMS's success in localizing Montessori teacher training in the United States and their commitment to helping Montessori education localize in other nations as well (Povell, 2010; Rambusch, 1962; Ungerer, 2016).

By the late 1990s and early 2000s, Montessori preschools continued expanding in China, leading to increasing demand for Montessori teacher training. In response, the two leading Montessori organizations globally, the Association Montessori Internationale (AMI) and the AMS, established Montessori teacher training in China in the 2000s. The AMS held their first diploma course in 2005 at Etonkids Montessori Teacher Training Academy in Beijing (personal communication, Montessori & More founder, Jemina Villanueva-Valle, February 2, 2019), while the AMI, the organization Montessori founded in 1929, held the first official AMI

diploma course in 2007 (AMI, 2020). Since, the AMI and the AMS have continued to hold diploma courses within China, contributing to the spread of Montessori education and its popularization.

Not only do the AMI and AMS hold Montessori training, but in response to the growing increase in Montessori education in China, grassroots Montessori training organizations have sprung up all over China offering Montessori teacher training as well. The largest Chinese-based Montessori training organization, the Chinese Montessori Society (CMS), is one such organization. Founded in 2002 by Duan Yunbo, the CMS conducts affordable teacher training in over 30 locations throughout China (CMS, 2020; Duan, 2006). CMS has undoubtedly contributed to the spread of Montessori education through teacher training, material manufacturing, and research publications (personal communication, CMS Dean of Education, Xiaojin Zhang, November 26, 2020) and continues to be a leading resource for Montessori education in mainland China.

Montessori preschools have expanded all over China as well since the late 1990s. Montessori preschools are traditionally private preschools, with only a few public Montessori preschools (Huo, 1999; Li, 2005; Liu & Lin, 2003; Yang, 2004). Montessori private preschools have succeeded in popularity, very likely connected to the "Walking with Two Legs" policy that encouraged private preschool education in the 1990s. This policy led to a massive increase in private preschools in general, creating competition in the market-based system. Private preschools began promoting various Western education methods to increase profits and attract parents, including Montessori. This, unfortunately, has led many to view Montessori education in China as a high-cost education system that creates inequalities within society (Li, 2005; Liu, 2010; Liu & Lin, 2003; Wang, 2011; Wang, 2012; Yang, 2004). These stated concerns are similar to those of the early 1900s when education was reserved for elite families only (Liu and Lin, 2003; Yang, 2004), and the question has been raised as to how to make Montessori education accessible to children from all socioeconomic classes (Meng, 2005; Yang, 2002).

While Montessori education continues to receive growing popularity, a recurring issue found in the literature is how Montessori education is localized to fit Chinese cultural and educational needs. This is a significant factor when reviewing the historical account of Montessori education, as localization directly determines the extent and effect to which Montessori education is accepted and spread within the society. How to address localization is also significant in identifying Montessori education's place within ECE practices in China and its potential for influence in the 21st century.

Localization of Montessori Education in China

Chinese research on Montessori education continues to discuss the topic of localization and sinicization (本土化, 中国化) (Deng et al., 2016; Huo, 1999, 2001; Liu & Lin, 2003; Tian, 2007; Tian, 2008; Tian et al., 2014; Wang, 2012; Yang 2002, 2004). Different from localization concerns in the early 20th century that were more technical (how to manufacture materials and how to teach Chinese writing), concerns of today are more philosophical in nature. Researchers today state that since Montessori education originates from a different time, place, and culture than China, philosophical elements of the method need to be taken out or adapted to fit a modern-day Chinese context. Understanding the elements of analysis approach, which states that the development and use of an education system reflect the cultural context from which it came (Gu, 2014), it cannot be denied that the climate in which Montessori education emerged played a role in its foundations. Wang (2012) writes ignoring the cultural context from which Montessori education originates and blindly implementing it without considering the national condition of China is like "rooting children in foreign soil" and educating them "to solve western problems".

As previously stated, when the PRC adopted Marxist education ideology in 1949, it specified that education and government went hand in hand as education would be the vehicle by which cultural values and the state's agenda would disseminate (Gu, 2014). As a socialist country with "Chinese characteristics" today (Choy, 2017), this use of education is still in place in China, and the argument for how Montessori education conforms to this particular usage of education remains at the forefront (Huo, 2001; Tian, 2007; Wang, 2012).

The main concern surrounding how to localize Montessori education is how to ensure Montessori education is implemented from a Chinese point of view. Specifically speaking, the research repeats that Montessori education must cultivate Chinese moral values and cultural characteristics (Deng et al., 2016; Huo, 2001; Liu, 2010; Wang, 2012; Yang, 2002, 2004), which includes cultivating collective identity in children (Deng et al., 2016; Huo, 2001) as these two concepts are fundamental functions of the

education system in China and it is essential that Montessori education possess and promote these beliefs as well.

Fostering Chinese Moral Values

Localization concerns as stated in the research surround the assumption that as a western education method, Montessori education does not respectively promote Chinese moral values, patriotism, or admiration for traditional Chinese culture (Deng et al., 2016; Huo, 1999, 2001; Wang, 2012; Yang, 2004), which are all fundamental functions of the education system in mainland China (Choy, 2017; Gu, 2014). Counter to Chinese culture, Yang (2004) writes that Montessori education promotes western values such as freedom of thought and action, development of the individual personality, and values each individual's unique ideas, where Chinese culture promotes modesty, restraint, submissiveness, and obedience (Choy, 2014; Yang, 2004).

The moral values of Chinese society are directly connected to Confucius ideology (Choy, 2017; Gu, 2014) and are at the forefront of Chinese culture, including Chinese education culture (Gu, 2014). Huo (2001) and Yang (2002, 2004) state that since Montessori was Catholic, Catholic ideology is inherently woven into the Montessori education system and before implementing the Montessori method, religious elements must be removed before it can be appropriately applied in China.

China is not the first nation to express concern over the religious undertones found in Montessori's writings and philosophy. AMS founder Nancy Rumbusch also dealt with concerns over religious ideology when localizing Montessori education in the U.S. While at first Montessori education in the U.S. was predominately adopted by families of the Catholic faith (Povell, 2014), Rambusch sought to remove Montessori education's association to the Catholic religion, as the method is ultimately designed following rules of human development and applicable to all children. Mario Montessori, Maria Montessori's son, supported this, stating, "'The Montessori method is like a medicine—there is no Catholic medicine" (Povell, 2014, p. 154), implying the universality of Montessori education for all children, not just children of a particular faith.

As a scientific pedagogy (Montessori, 2012), Montessori education is not limited to religious or culturally specific contexts. Montessori's theories of development apply to children of all backgrounds regardless of religion as it is based on the fundamental laws of human development as observed by Montessori. Including China that possesses its own cultural principles, Montessori education is an applicable pedagogy as its fundamental philosophies are designed according to developmental characteristics universal to all children. Montessori writes, "The art of education must become a service to these powers inherent in all children. It must be a help to life" (Montessori, 2012, p. 18). These inherent powers she speaks of are what Montessori termed sensitive periods—stages of development universal in all children that lead children to acquire specific skills or abilities essential to life. Sensitive periods and other critical components of Montessori's developmental theories are founded on truths of human development, making the Montessori philosophy applicable to all children from all backgrounds.

Building Collective Identity

Emphasis on social relationships and cultivating collective identity are also explicitly stated concerns surrounding the implementation of Montessori education in China (Deng et al., 2016; Yang, 2002, 2004). Chinese culture is at its core a collectivist society, and social relationships are the basis for the functioning of the society (Choy, 2017). Yang (2002, 2004) questions whether children in Montessori classrooms cultivate collective identity seeing that in Montessori classrooms, children spend more time working independently from each other and the teacher than is typical in non-Montessori schools. It is suggested that in this way, children are not given adequate opportunity for social and emotional growth as most time is spent silently working alone. Deng et al. (2016) also highlight this aspect and suggest Montessori classrooms localize by holding more group lessons and whole-class activities to aid in the cultivation of a collective identity.

Yang (2002, 2004) and Deng et al.'s (2016) perception of this issue stems from a misunderstanding about Montessori education as Montessori did emphasize the importance of social relationships amongst the children, the difference being the basis for these experiences. Consideration for the group and understanding one's role as a member of the group is what Montessori described as the highest awareness in social development as children learn about themselves and their relationship to the group, and for the harmony of the group, will put other's needs and the group's needs above their own. She saw that what she called "normalized" children (children who exhibit self-controlled, purposeful, organized behavior) think about themselves in relation to the group in the classroom and make choices that not only benefit themselves but

that reflects an understanding of the classroom society (Montessori also used the phrase "spirit of the family of the tribe," Montessori, 1967/1995, pg. 232). This happens through the children's daily experiences interacting with each other, caring for each other and the environment, solving social problems together, learning to wait, and learning from each other. In Montessori classrooms, exercises and experiences that cultivate a collective identity happen daily as children partake in the classroom society.

As can be seen, Montessori education does uphold values associated with a collective identity, the only difference being in the organization of the experience. While in non-Montessori classrooms, it is perceived that social cohesion comes by keeping the children together as a group, Montessori believed social cohesion was the result of interactions amongst the children. Children in a Montessori classroom take part in their own society and learn to cooperate and help one another.

Simultaneously, Montessori was clear that the development of the individual was of equal importance. Montessori writes, "Individuality is the basic unit, the fundamental building block of a society, which is made up of many individuals, each functioning autonomously but associating with others for the common purpose" (Montessori, 1999, p. 55). What Montessori is highlighting here is the importance of the development of the individual so that the child may have a contributing role within his society. While Chinese culture and education may emphasize collective identity more so than the individual, Montessori saw these two developments as complementary and of equal importance. This can be seen in the Montessori classroom as children help one another and care for one another, yet progress in the Montessori apparatus according to their individual developmental needs (Montessori, 1967/1995).

While Chinese research expresses caution and concern when implementing Montessori education to ensure cultural, societal, and national integrity, as can be seen, elements of the method naturally share values consistent with the Chinese nation, creating a harmonious relationship between the two. Considering that Montessori education is based on human development principles, the essence of the method remains intact when religious ideologies are removed. Thus, Montessori education does fit within a Chinese context. Finally, Montessori education does emphasize the importance of societal relationships, the slight difference being the duality of cultivation of the self as well as the society, for a balanced, agreeable reality.

Conclusion

Montessori education has been an advancing educational philosophy in mainland China since the 1990s and enjoys popularity today. Considering the overall historical account of ECE in China, Montessori education has benefitted from a series of ECE policies supporting the privatization of ECE programs resulting in curiosity toward western ECE ideologies in the 1980s and 1990s.

Simultaneously, aspects of localization need to be addressed and understood in order for Montessori education to continue to spread in mainland China in the 21st century. One of the primary goals of ECE in China is the transmission and cultivation of cultural values. As has been presented, Montessori education does share principles cohesive with Chinese culture. In order for Montessori education to continue to appreciate recognition within China, it is imperative that Chinese Montessori researchers grasp a deeper understanding of Montessori principles and practically implement a Chinese-centric Montessori program that supports child development according to Montessori philosophy that also identifies with and prioritizes a Chinese identity and perspective.

Competing Interests

The authors have no competing interests to declare.

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The Challenges and Opportunities of Implementing Montessori Education in the Public Sector

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Keywords: *Montessori fidelity, public Montessori, Montessori student demographics*

Abstract: Over the past two decades, Montessori education in the United States has rapidly expanded from the private to the public sector. This expansion has created important questions about whether or not the Montessori approach can thrive alongside the education standards and accountability movement in the public sector. Questions also exist as to precisely who is benefitting from this expansion of and investment in public Montessori. To examine these topics, this study focused on South Carolina, the state with the highest number of public programs in the United States. We used implementation surveys, classroom observations, and teacher interview data collected by the research team and student record data collected by the state of South Carolina to conduct the analysis, which consisted of three parts. First, we investigated to what extent public programs in South Carolina are able to implement Montessori education with fidelity to the model. Second, we considered what program characteristics were related to higher levels of Montessori implementation fidelity. Third, we analyzed which children had access to higher-fidelity Montessori programs. Generally, findings indicated that, despite challenges created by the education standards and accountability movement and concerns expressed by educators about authenticity, most programs in South Carolina were implementing Montessori with fidelity. Several characteristics were associated with higher levels of fidelity, including the age of the program. Findings also indicated that Black, Hispanic, and students from low-income families were disproportionately participating in lower fidelity programs. Our study provides an in-depth analysis of the challenges and opportunities associated with government trying to implement successful private-sector education models in the public sector.

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Introduction

In the over 100 years since Dr. Maria Montessori developed her child-centered educational approach, Montessori education has rapidly spread across the world. As the access to Montessori has grown, it becomes more difficult to ensure adherence or fidelity to the central tenets of the Montessori model. This challenge is exacerbated by the standards and accountability educational reform movement, as it is referred to in the United States, which offers an approach to education that often conflicts with tenets of Montessori. The Montessori model emphasizes student-guided work rather than the rigid standards emphasized by this top-down approach. Further, evaluation by standardized tests is largely antithetical to the Montessori method, which emphasizes intrinsic motivation and learning at a student's own pace. The key tenets of the Montessori approach are graphically presented by Culclasure et al. (2019) in the form of a logic model with key program inputs, outputs, and outcomes discussed.

The tension between fidelity to the Montessori model and the education accountability movement is quite visible in public Montessori implementation in the United States. From the creation of its first school in the United States in 1911, Montessori education has earned much acclaim within the private school community for its overall approach to teaching and student learning. Its entrance into public education has been slower, but over the last several decades, Montessori has begun to gain a foothold in America's public schools (Whitescarver & Cossentino, 2008).

As the prevalence of Montessori education continues to expand in the United States public sector, questions have emerged regarding how well the Montessori approach fits with standards and accountability reforms. Little currently is known about how Montessori is being implemented in public schools and the possible effects of Montessori education on public school students.[1] Can higher fidelity Montessori education be implemented in the public sector? If so, who has access to these programs? To examine these topics, we developed a study of public Montessori implementation in the state of South Carolina. The study consists of three parts. First, we used multiple methods to investigate the extent to which public Montessori programs were implementing the Montessori model with fidelity. Second, we considered which factors were associated with higher levels of Montessori program fidelity in South Carolina. Last, researchers considered which student populations had access to higher fidelity Montessori programs and which did not.

The Montessori Model and Education Reform

Many aspects of Montessori education are quite different than the status quo in most traditional American public schools today. Montessori education provides a "child-centered" approach to schooling, as opposed to the arguably "one-size fits all" approach of some public schools. Further, some aspects of Montessori education seem to conflict with current standards and accountability movement. While the Montessori curriculum outlines what students should learn, the pacing is individualized to fit the interests and abilities of the student (Montessori, 1964). The role of the teacher is also different in Montessori schools. Rather than teaching from the front of the room, Montessori teachers interact with students in small groups or on a one-to-one basis as students work independently (Block, 2015; Montessori, 1964). Teachers are well-trained to be facilitators and humble observers, preparing a carefully crafted learning environment (Montessori, 2020). The organization of the classroom is unique. Typically, in public Montessori schools in the United States, students aged 3–6 (primary level), 6–9 (lower elementary), and 9–12 (upper elementary) are in the same classroom for a three-year span with the older students often mentoring or assisting the younger students (Lillard, 2012; Montessori, 1964). Rather than traditional scripts, textbooks, and worksheets, the Montessori method relies on the usage of Montessori learning materials that encourage hands-on learning. The environment in a Montessori classroom is orderly, pleasant, clean, and safe for children.

Not surprisingly, assessment in a classroom implementing high fidelity Montessori education is much different than it is in a traditional public school classroom. Montessori teachers make observations of students as the students work; teachers take consistent and comprehensive notes on how students are performing (Block, 2015; Montessori, 1964). Based on these observations, students and teachers create individualized work plans and learning goals. Fundamentally, the Montessori approach prioritizes intrinsic motivation and the development of the whole child, including creativity, respect for self and others, cognitive and socio-emotional abilities, and a sense of community (Block, 2015; Lillard, 2012; Montessori, 1964).

As public school choice options, such as magnet schools and charter schools,[2] have increased in the U.S., education reformers have increasingly looked at the Montessori model as a way to provide an innovative approach to education in the public sector. As of 2016, there are approximately 150,000–200,000 public Montessori students attending over 550 public Montessori schools across the United States (Sparks, 2016). According to a survey of charter schools by the Center for Education Reform (2014), Montessori was the seventh most popular academic theme for charter schools behind College Prep, Core Knowledge, STEM, Blended Learning, Constructivist, and Back to Basics. Montessori was more popular than other themes such as Fine Arts, Virtual/Online, Bilingual/Foreign Language, and Vocational Education. Analyses of parental decision-making when it comes to school options for their children often find that the quality of curriculum and instruction and a particular approach to education, like Montessori, are important school characteristics that parents consider (Bosetti & Pyryt, 2007; Bukhari & Randall, 2009).

Public Montessori programs are commonly understood to be a good fit for charter school and other public school choice models. On the one hand, public Montessori stands in stark contrast to the traditional public school model. On the other hand, Montessori in the public sector may not be seen as a "risk" for charter school authorizers due in part to its long, strong track record in the private sector and in the public sector since 1967, which marked the opening of the first public Montessori school in Reading, Ohio (AMS, 2022). Therefore, Montessori education seems to provide an innovative, yet not overly "risky" alternative for public education reformers, which is likely why it has increased in popularity over the last several decades.

In contrast to its natural suitability with the public school choice movement, the Montessori model's fit within the standards and accountability movement is less certain. The focus on common standards, high-stakes testing, and increased accountability for teachers and schools are part of what Sahlberg (2016) calls the "Global Education Reform Movement" (GERM). Since it's conception in the United States and England in the late 1980s, GERM has spread to many countries throughout the world, from Central and Eastern Europe, to South America, the Middle East, South Africa, and East Asia. International organizations have often fostered GERM. The World Bank has promoted increased education accountability and standards since the 1990s, and a 2017 UNESCO report argued that without improved accountability global educational goals will not be met. Högberg and Lindgren (2021) find that the term "accountability" is mentioned more than 500 times in the 2016 OECD publication, *Governing Education in a Complex World*. These calls for increased accountability have led to policy change in many countries. PISA data indicate that school accountability policies have become more prevalent in participating countries from 2000 to 2015 (Högberg & Lindgren, 2021), and Verger et al. (2019) find that the delivery of standardized curricula is increasingly being monitored by national education systems through the use of large-scale standardized testing.

Various studies have examined the possible negative consequences of this movement (e.g., Nichols & Berliner, 2007; Ravitch, 2011). State-mandated testing regimes can lead to teachers narrowing the curriculum, to spending large amounts of time on test-taking strategies, and, ultimately, to teacher burnout (Abrams et al., 2003; Berryhill et al., 2009).

These general concerns regarding standards and accountability are heightened in public Montessori programs, as the standards and testing approach are largely antithetical to the Montessori model. This is a growing concern, as a review of 101 education systems by UNESCO (2017) found that 95% had some type of national testing. Shortly after the federal No Child Left Behind Act was passed in 2001 in the United States, which mandated state standards and annual standard testing, the American Montessori Society (AMS) (2002) issued a press release that quoted the AMS national director, Michael Eanes: "Mandated proficiency testing represents a diametric departure from the Montessori educational model because it fragments the educational experience, separates schooling from life and limits opportunity for autonomous learning and choice."

Montessori educators and researchers believe that narrow standardized tests are neither an adequate nor an appropriate measure of student learning. In one study, Rathunde and Csikszentmihalyi (2005) compare the attitudes of students in primarily private Montessori schools that did not have a standards and accountability approach to other students attending traditional public middle schools. They found that Montessori students felt higher levels of affect, undivided interest, and intrinsic motivation when engaged in academic work at school than traditional public school students. Montessori students found approximately 40 percent of their schoolwork intrinsically motivating and important, compared to traditional public school students who felt

the same way only 24% of the time. According to one proponent of Montessori education, "When the stakes for children are high (as when the tests determine whether they can proceed to the next grade or graduate), the tests produce feelings of fear and dread. To those of us who want children to love learning, test-driven education is a disaster" (Crain, 2003, p. 10). Research from the United States indicates that private Montessori schools are 39% less likely to participate in a school voucher programs than traditional private schools are (DeAngelis, 2020), possibly because Montessori school leaders are wary of increased governmental regulation and standardization, including state testing requirements, which could conflict with the Montessori model (DeAngelis et al., 2021). In addition to the philosophical tensions between Montessori education and the accountability movement, there are also more practical challenges. The multi-age classrooms and individual pacing of learning make it difficult to match Montessori to specific grade-level standards (Jacobson, 2007; Murray & Peyton, 2008). Further, the Montessori model includes long uninterrupted blocks of work time; therefore, its students are not used to and thus at a disadvantage for the timed assessments associated with standardized tests (Lillard, 2016).

Implementing the Montessori Model in Public Schools

Implementation fidelity is an important component in evaluating the success of public policies and programs. Simply put, implementation fidelity can be defined as "how well a program is implemented relative to the original or the ideal" (Lillard, 2012, p. 380). Fixsen et al. (2013) note that improved student outcomes from effective interventions can only be realized through effective implementation, but the majority of education evaluation research focuses on narrow program evaluations while largely overlooking how to successfully implement and scale up successful programs. By ignoring implementation fidelity, evaluators run the risk of committing Type III error, which is concluding that a program was ineffective when in actuality it was not implemented with fidelity (Dusenbury et al., 2003). Scaling up interventions in a way that maintains high levels of fidelity can be very difficult and can create a host of challenges (Glennan et al., 2004).

These implementation challenges are even more significant in the public Montessori context. Given the inherent tensions between the Montessori model and the standards and accountability movement, it is an open question as to whether public school students participating in Montessori programs receive a "true" Montessori education. There is some reason to believe that public Montessori teachers are able to implement the model with a high level of fidelity. According to one survey of Montessori principals, only 13% strongly agreed that standardized testing in the school "compromises the character of the Montessori program" (Murray & Peyton, 2008). Teachers, as street-level bureaucrats (Lipsky, 1980), generally have the discretion to act in a way to fit the needs of students and the teachers' professional beliefs. Goldstein (2008) notes how teachers interpret district, state, or federal policies through their professional lenses as teachers. Teachers do not simply parrot state standards and proctor standardized exams. Another reason to believe that a higher fidelity Montessori model can still thrive in the public sector is that a large percentage of public Montessori education is at the pre-kindergarten (PK) to early elementary level. Since most state-mandated testing regimes in the U.S. start in third grade, perhaps many Montessori programs are spared the accountability testing pressure.

However, there is considerable evidence that implementing higher fidelity Montessori education in the public sector is difficult because of federal, state, and district mandates, including standards and accountability tests. Public Montessori schools realize that they must show strong results on the state tests or risk losing support. According to one public Montessori principal, "We see more stress on the teachers. It's really against their philosophy to test their children. But if we don't show that this program helps children perform, then [school system officials] will do away with our program" (Jacobson, 2007). While it is true that only upper elementary, middle, and high school students face high-stakes standardized testing in the United States, the standards and accountability mindset also permeates the younger grades, even in Montessori schools (e.g., Gonzalez, 2014; Jacobson, 2007). Perhaps, these tensions are too strong, as only 28% of public Montessori principals strongly agreed that they implement the Montessori program "according to the original version of Maria Montessori" (Murray & Peyton, 2008). This may indicate that Montessori schools are changing curricula to meet the demands of districts and states in an effort to ensure the longevity of their.

Education researchers have lagged behind those in other policy areas in terms of recognizing the importance

of studying fidelity of implementation (O'Donnell, 2008), and this shortcoming has permeated Montessori research as well. Evaluations of Montessori programs have generally assumed high levels of fidelity without directly examining it. This may be one reason for the inconsistent results of Montessori evaluations (Lillard, 2012). However, a growing number of Montessori researchers are examining this question (e.g., Block, 2015; Daoust & Suzuki, 2014; Lillard, 2012; Scott & Glaze, 2017). Daoust and Suzuski (2014) find great variation in implementation fidelity to the Montessori model in public Montessori schools. Block's (2015) case study of a public Montessori school in the U.S. found that Montessori school officials change classroom practices, assessments, and curriculum in a way that diminishes fidelity to the Montessori model in order to meet governmental mandates. Teachers developed work plans for students based on individual grade levels within the mixed-age classrooms and changed assessment procedures to prepare students for state standardized tests. "Second- and third-grade students were explicitly taught test-taking skills for one hour each day for six weeks in an attempt to raise the school's assessment scores" (Block, 2015, p. 48). This means that the child-centered classroom shifted to a more teacher-directed learning environment with more rigid timetables.

An examination of the fidelity to the Montessori model in the public sector is more than just a "truth in advertising" exercise.[3] It can have important implications for student outcomes. Lillard (2012) compares the academic performance of three sets of students: those attending private, high fidelity Montessori programs; students in private, low fidelity Montessori programs that supplemented the program with conventional schoolwork; and a conventional comparison group attending nearby private schools. Those students in the high fidelity Montessori programs exhibited more positive student outcomes than both of the other groups. This finding is consistent with the literature that finds high fidelity implementation is a key component for effective programs (O'Donnell, 2008). Given that Lillard's (2012) analysis focused on private Montessori schools, further questions need to be asked about public Montessori programs.

It also is important to consider who has access to higher fidelity Montessori programs. In the private sector, Montessori education is often seen as an elite, largely-white education option. However, Maria Montessori started her career by educating poor children in the slums of Italy. The history of public Montessori in the United States demonstrates that the Montessori approach to education has been attractive to a diversity of parents (Debs, 2019).

Previous research indicates that high fidelity Montessori pedagogy can significantly increase student learning (Lillard, 2012). However, not all public school students have equal access to higher fidelity Montessori (Debs, 2019). When public Montessori students are compared to other students in the surrounding area, there is evidence that white students are overrepresented in public Montessori programs (Brown, 2016; Culclasure et al., 2018; Debs, 2016). Debs and Brown (2017) also note several cases in which Montessori charter applications or renewals have been denied or given increased scrutiny because of concerns that these programs may increase racial isolation in public schools.

These considerations and others highlight the need to explore not only which types of students are being served by public Montessori, but also whether or not certain groups are concentrated in higher fidelity schools. Are higher fidelity public Montessori schools over populated by high-income students? Do mostly white students attend these schools, leaving children of color learning in schools classified as lower fidelity? These important questions are addressed in this study.

Study Design and Research Questions

The Montessori model seems like a promising way to provide a unique approach to education in the public sector and studies have shown that exposure to higher fidelity Montessori programs has increased student achievement more than conventional private schooling (Lillard, 2012). However, given federal, state, and district mandates, it may be difficult to implement high fidelity Montessori programs in public schools. As outlined above, there are important questions as to whether higher fidelity Montessori education can be implemented in public schools given the global standards and assessment movement. In addition, there are questions about who and which types of families are served by these schools.

To examine these questions, we developed a study of public Montessori education that focused on the state of South Carolina. Whereas other evaluations of public Montessori education have examined a small number of Montessori schools (Lillard et al., 2017; Lillard & Else-Quest, 2006), this study focuses on all of South Carolina's 45 public Montessori programs. As of 2022 and has been the case for years, this represents the largest number of public Montessori programs in the United States

(NCMPS, 2022). Montessori programs in South Carolina are found in all levels of schools and are classified in the following way: students ages 3–6 (primary level); ages 6–9 (lower elementary); ages 9–12 (upper elementary); and secondary programs for ages 12+. This study focused only on the primary, lower elementary, and upper elementary levels.

Listed below are the three research questions this study explored:

Research Question 1: To what extent is the Montessori model being implemented with fidelity in South Carolina's public Montessori schools?
Research Question 2: what program characteristics are associated with higher levels of fidelity to the Montessori model in public Montessori schools in South Carolina?
Research Question 3: what types of students have access to higher fidelity public Montessori schools in South Carolina?

Methodology and Instruments

Measuring Fidelity to the Model

Measuring fidelity to the Montessori model was key in addressing all three research questions. At the time of this study, no validated instrument existed that could be used to measure program fidelity in Montessori schools. We thus created a new instrument to measure fidelity for use in this study. In our case, it was crucial as researchers that we were able to observe directly the classroom environment to see what teachers were doing in the classroom and how students were learning. We understood that a true measure of fidelity required having specifically trained observers using valid tools to closely examine the teaching and learning taking place in enough classrooms to be able to draw conclusions.

After much consideration, we decided upon two methods to measure fidelity to the model that allowed us to classify schools into one of three fidelity levels. First, we administered an in-depth implementation survey to the principals of all Montessori programs across the state. Second, we measured fidelity via observations of Montessori classrooms using researcher-created instruments. These observations included a short post-observation interview with the teachers observed to obtain more detailed information about classroom practices and methods. We collected four years of observation data (2012–13, 2013–14, 2014–15, 2015–16) and observed at every program in South Carolina. Excluding pilot data, a total of 99 classrooms were included in the study.

Regarding the implementation surveys, Montessori principals completed the survey about their school's Montessori program each year. Surveys were developed by the research team and underwent an extensive review by the project's Montessori expert consultant, as well as leaders from numerous national and statewide Montessori organizations including the American Montessori Society (AMS) and the National Center for Montessori in the Public Sector (NCMPS). The implementation survey focused on four critical implementation factors: multi-aged groupings, teacher training, uninterrupted work period, and Montessori materials.[4] During the course of the study, we collected four years of survey data (2012–13, 2013–14, 2014–15, 2015–16) via a web-based administration process. We received at least one survey from each of the different public Montessori programs across the state during the four years of the study.[5] See Appendix A for a copy of the principal survey instrument.

Schools not meeting a minimum threshold for fidelity on the programmatic implementation survey were not included in further classroom observations, as we determined that they could not even be considered a low fidelity school without basic tenets of Montessori implementation. Programs that met the minimum threshold for fidelity on the programmatic implementation survey were promoted to the classroom observation and teacher interview process.

Classroom observations and teacher interviews took place in randomly selected classrooms and during the uninterrupted work time. The observation process consisted of an unannounced hour-long classroom observation followed by an informal interview with the teacher. The purpose of the observation was to assess each classroom's prepared environment, classroom climate, student learning, and teacher instruction. The purpose of the post-observation teacher interview was for the observer to examine how the teacher conducted lesson planning, record keeping, and assessment of student progress.

Classroom observations/interviews were conducted by retired Montessori teachers and teacher trainers who met stringent credential requirements and had prior experience in a Montessori public school setting. All observers had a Montessori credential for the level they observed. Observers also underwent extensive training conducted by the project Montessori expert consultant

and the principal investigator prior to conducting observations.

The instruments used by observers were developed by the study team and the Montessori project expert consultant. The main resources used to develop this instrument include Lillard's (2016) Eight Principles of Montessori Education, the Classroom Assessment Scoring System, an observation instrument to assess classroom quality in pre-school (Pianta, 2003), and Montessori Classroom Observation Checklists from several national Montessori organizations. The instruments then were reviewed by leaders in a variety of national and statewide Montessori professional organizations including the American Montessori Society (AMS) and the National Center for Montessori in the Public Sector (NCMPS). The instrument was piloted across classrooms in South Carolina. An inter-rater reliability study was conducted to establish and confirm the reliability of the data collection instruments.

There was a separate observation instrument for the three levels of classes that were observed, each with its own unique set of indicators that are widely accepted as being necessary for Montessori classrooms of high quality (i.e., adhering to the principles and method of Montessori education). Please see Appendix B for a copy of the observation instrument and the post-observation teacher questionnaire.

Scoring

In order to simplify the scoring of the surveys, we selected three critical questions focusing on Montessori materials, multi-aged grouping, and uninterrupted work periods, and based the implementation survey score on answers to these questions. For example, we asked about the existence of multi-aged classrooms, an important component of Montessori. If the principal reported that all the classrooms were properly multi-aged, the answer received a ten. If 76% to 99% were properly multi-aged, the answer received an eight; 51% to 75% received a six; 26% to 50% received a four; 1% to 25% received a two; and if none of the classrooms were properly multi-aged, the answer received a zero. This scoring technique was used for the remaining questions. Given that principals received the implementation survey each year, we created average scores across all four years for which data were available (since schools may have submitted a survey for all years of the study, or they may only have submitted a survey for one, two, or three years).

To score the classroom observations/interviews, observers used rubrics to quantify their observations. It is important to emphasize that these are criterion-referenced measures, meaning that each observation or interview is compared to the rubric to produce a value. The indicators for all three levels were divided into the same areas: Prepared Environment, Classroom Climate, Student Learning, Teacher Instruction, and Assistant Instruction. There were between 10 and 15 indicators for each of the five areas. The rating scale for each indicator was Met, Somewhat Met, or Not Met. All indicators were treated alike and assigned points as follows: Met = 2; Somewhat Met = 1; and Not Met = 0. Points were tallied and divided by the maximum number of points that could be earned to derive a percentage score. Scoring for the post-observation interview focused on Lesson Planning; Recordkeeping; and Student Assessment. Interview responses also were scored as Met (2), Somewhat Met (1), or Not Met (0) based on information recorded by the researcher on a matrix. The results of the entire observation were scored in a way that provided a percentage score for the observation and a percentage score for the post-observation interview. Once percentages were calculated for these two pieces, they were averaged, and a total percentage score was determined for each classroom.

Working with our Montessori consultant, who had vast experience with South Carolina's Montessori programs, we used our observation data, teacher interview results, and the implementation survey data to create a classification scheme of Montessori fidelity by program. This would allow us to make comparisons between programs with different levels of fidelity. We labeled programs as falling into a high, medium, or low fidelity category. Importantly, these are not relative fidelity rankings; rather, programs were compared to the components that were identified as necessary for higher fidelity Montessori implementation.

Sampling Procedures

Given that there were approximately 315 Montessori classrooms in public South Carolina schools at the start of the four-year study, we knew it would be impossible to measure fidelity in all classrooms each year. Therefore, we employed a stratified random sampling technique where we observed at least one classroom at every school across the state during the course of the study, and based the number of classrooms observed on the size of the school (i.e., the more classrooms a program had, the higher number of classrooms observed at that school[6]).

We also took into consideration the levels of Montessori provided at each school (primary, lower elementary, and upper elementary) and sampled classrooms to ensure a proportional representation of levels of Montessori. Our goal was to observe a consistent percentage of classrooms across all levels of Montessori and in all programs. Including our pilot observations, we visited 126 classrooms across the state. Our analytical sample included 99 classroom observations from 45 Montessori programs. Seventeen programs had one classroom visit, 17 programs had two classroom observations, and the remaining 11 programs had between three and eight visits. Since principals of all Montessori programs across the state were administered the implementation survey each year of the study, no sampling procedures were necessary with the implementation surveying process.

Data Analysis Procedures

In this study, we incorporate the data from classroom observations, teacher interviews, and principal surveys described above with the South Carolina student record database, PowerSchool.[7] The student record data include all public school students in South Carolina in 2015–16. Importantly, this database has an indicator variable for students who are enrolled in a Montessori program. To ensure the validity of the Montessori variable, the research team worked with Montessori schools to ensure the correct coding of the variable. This was particularly important, as many South Carolina public Montessori schools have a program-within-a-school structure, which means that a school may provide both Montessori and traditional classes. For the purposes of this study, we treat Montessori programs that operate as a program-within-a-school, as if they were separate schools. For example, when we discuss the demographics of Montessori students in a program-within-a-school, we only use data for those students who received Montessori education, not all students enrolled in the school.

While the classroom observation and teacher interview data provide information at the classroom level, the principal surveys only provide school or program-level data. The student database does not provide a way to aggregate students to the classroom-level. The analyses to examine the fidelity of Montessori implementation (Research Question 1) are at the classroom-level, while the analyses to examine the factors associated with high fidelity (Research Question 2) are at the program/school-level, and the analysis of student access to high fidelity Montessori (Research Question 3) is at the student- and school-level. Classroom observation and teacher survey data were averaged across classrooms, teachers, and years to create school-level measures for these factors.

This study provides a descriptive investigation of public Montessori in South Carolina. The quantitative analyses performed in this study are meant to illustrate the state of Montessori education, rather than to test specific statistical hypotheses. In addition to providing univariate results, we provide bivariate comparisons to examine differences by fidelity level. All analyses were conducted using the Stata software program.

Results & Analysis

Research Question 1: To what extent is the Montessori model being implemented with fidelity in South Carolina's public Montessori schools?

We first described the results of our classroom observations and teacher interviews. Excluding our pilot data, our research team examined 99 Montessori classrooms throughout public schools in South Carolina. Using the rubric described above, trained Montessorians examined each classroom on a number of dimensions. Figure 1 presents histograms of the classroom observation scores by area. For each of the five areas, classrooms received a score between 0% to 100%.

One sees that classrooms generally received high marks. This was particularly true in terms of classroom climate with the average score being 93%. Observers generally found that classrooms also had high levels in terms of student learning (mean of 87%), teacher instruction (mean of 85%), and assistant instruction (mean of 86%). Observation scores were the lowest for prepared environment with an average score of 74%. A focus on the average score, however, overlooks the variation in classrooms on these dimensions. Eighty-eight percent of classrooms scored at least 80% on classroom environment, demonstrating that there was broad success in this area. Less than 10 percent of classrooms scored below a 60% for student learning, teacher instruction, and assistant instruction, again showing that most classrooms were at least adequate on these measures. The prepared environment shows more variability. While about 45% of classrooms scored at least 80% on this measure, 20% of classrooms scored at or below 59%, demonstrating that a significant proportion of classrooms lacked the necessary Montessori materials. This may be evidence

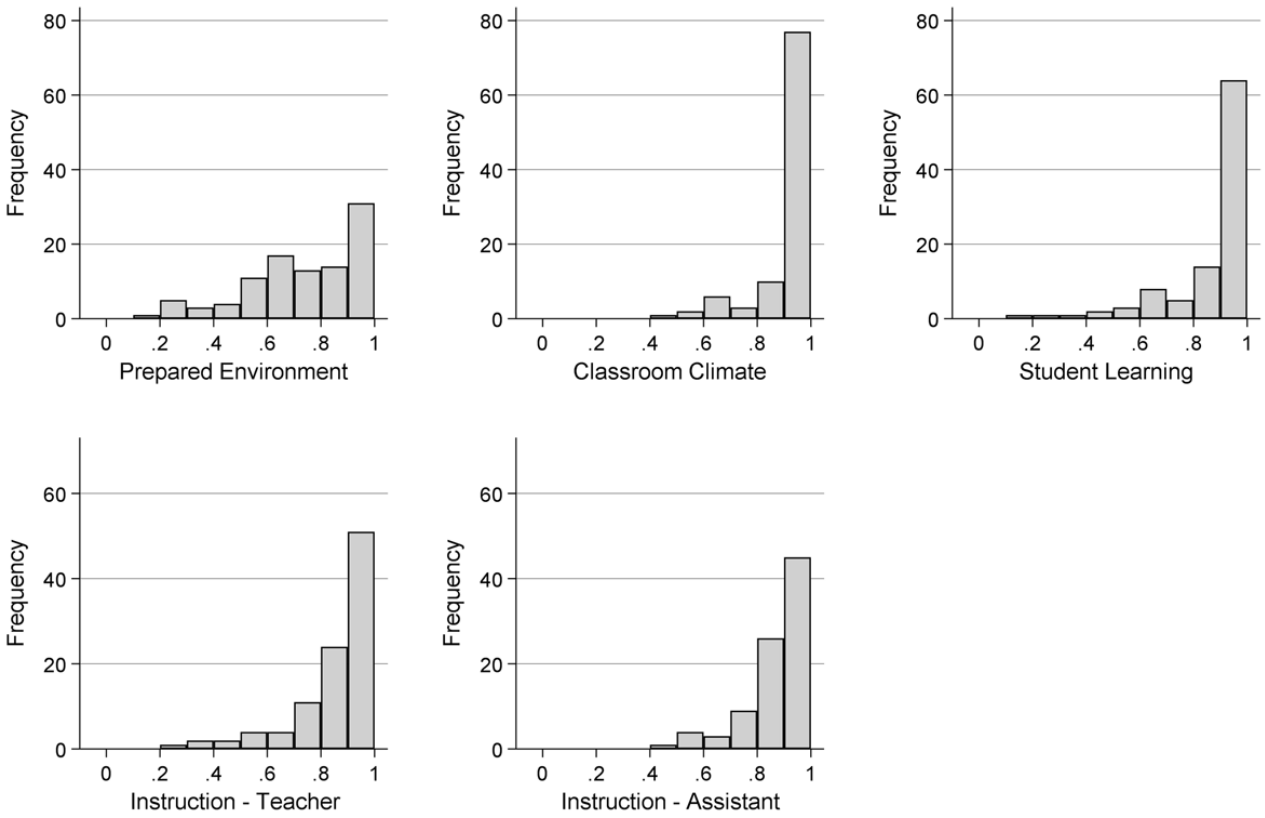


Figure 1
Histograms of Observation Scores

that some Montessori programs do not have the resources to fully implement the Montessori model. Or, it could be that some classrooms simply were not displaying all the available materials are the time of the observation, or had them stored out of view of the observer.

Scores from the teacher interviews are presented in Table 1. Classrooms received average scores of 83% for lesson planning, 79% for record-keeping, and 84% for student assessment. Unlike the observation areas which included multiple items, for these three outcomes, the observers measured items as either met, somewhat met, or not met. For all three factors, approximately 70 percent of classrooms met the standard. For both student assessment and lesson planning, about 27 percent of classrooms somewhat met the criteria and only 3% did not meet them. For record keeping, the results are different. An equal number of classrooms were coded as somewhat met or not met, about 14% each. While most classrooms are doing well on these three dimensions, a number of classrooms are below true fidelity on record keeping.

We also measured fidelity through programmatic

Table 1
Histograms of Implementation Survey Scores.

	N	MEAN SCORE	NOT MET	SOMEWHAT MET	MET	TOTAL
Student Assessment	99	84%	3%	26%	71%	**100%**
Lesson Planning	99	83%	3%	27%	70%	**100%**
Record Keeping	99	79%	14%	14%	72%	**100%**

implementation surveys administered to all principals of public Montessori programs across the state. For the histograms presented in Figure 2, each observation pertains to a Montessori program with scores (0–100%) from the survey averaged across years in which a survey was completed. Data from 52 different Montessori programs are examined here. Using these data, one sees that most programs display a relatively high level of fidelity on these factors. This is particularly true of the Work Period variable for which over 50% of programs scored a 100%, and the Materials variable, 88% of programs received a score above 80%. While the principal survey indicates that Montessori programs have the necessary materials, the classroom observations were a bit more skeptical. The distribution of the Multi-aged Classes variable is more spread out, as there is greater variation in programs on this variable. While 38% of programs scored a 100%, another 28% scored 59% or lower. It is on this dimension that more Montessori programs need to improve to reach higher levels of fidelity.

Research Question 2: Which factors are associated with higher levels of fidelity to the Montessori model in public Montessori schools in South Carolina?

In order examine to the second and third research questions, we created a single, program-level measure of Montessori fidelity. We placed programs in high, medium, or low fidelity categories. Importantly, these are not relative fidelity rankings; rather, programs were compared to the components that were identified as necessary for higher levels of fidelity implementation. These analyses include the 45 Montessori programs for whom we have fidelity data from our observational visits. At the program-level, we found that 23 programs were placed in the higher fidelity category (51% of the total), 14 in the mid fidelity category (31%), and 8 in the low fidelity category (18%). The median observation score for the high fidelity category was 92%. It was 84% for the mid fidelity category and 60% for the low fidelity category. The higher fidelity programs were able to follow the most important tenets of the Montessori model within the public sector. The mid fidelity programs may be similar to the "Supplemented Montessori" programs that Lillard (2012) observed, which combined Montessori education with traditional classroom activities. The lower fidelity programs often lacked appropriate Montessori materials, failed to offer multiage classes, and did not maintain proper record keeping.

We then merged our student-level public student data with our fidelity score ratings.[8] According to data from 2015–16, 7,218 public school students attended a Montessori program that we observed at least at some point over the four years of observation. Table 2 presents data on how high, mid, and lower fidelity programs differ based on student enrollment, the structure of the program, the type of program, and the longevity of the program. On average, Montessori programs enroll about 180 students. However, this number is skewed by the fact that some programs served a very high number of students. When examining the median, or 50th percentile, enrollment in Table 2, we found that the typical program had about 130 students. Enrollment differed by fidelity status. Mid fidelity programs generally had the largest enrollments, followed by high fidelity, and then low fidelity programs. Additional analyses showed that at the low end of the enrollment distribution, there was a diversity of different fidelity levels. Some small programs exhibited high fidelity, while others were mid or low fidelity. In programs with over 150 students, there was much less variation in fidelity scores with most programs being mid- or high fidelity.

Table 2
Program Characteristics by Fidelity Level

	HIGH FIDELITY	MID FIDELITY	LOW FIDELITY	TOTAL
	(N)	(N)	(N)	(N)
Enrollment (mean)	157.9	243.9	108.7	180.0
Enrollment (median)	110.0	257.5	88.0	131.0
	(21)	(14)	(6)	(41)
Whole School	50%	50%	0%	100%
	(2)	(2)	0	(4)
Program w/in School	51%	29%	20%	100%
	(21)	(12)	(8)	(41)
District	51%	29%	20%	100%
	(18)	(10)	(7)	(35)
Magnet/Charter	50%	40%	10%	100%
	(5)	(4)	(1)	(10)
Age of School: 10+ Years	59%	29%	12%	100%
	(10)	(5)	(2)	(17)
Age of School: 4–9 Years	52%	33%	14%	100%
	(11)	(7)	(3)	(21)
Age of School: 1–3 Years	29%	29%	43%	100%
	(2)	(2)	(3)	(7)
Total	51%	31%	18%	100%
	(23)	(14)	(8)	(45)

We were able to examine other program characteristics, as well. Four Montessori programs are whole-school Montessori programs, while the vast majority of Montessori programs with fidelity data in our study have a program-within-a-school structure. This means that a school will have both Montessori and traditional programs. Given the small number of whole-school programs, it is difficult to make true comparisons between the fidelity levels of combination and whole-school programs. Two of the whole school programs are high fidelity, while the other two schools are mid fidelity. There are no low fidelity whole-school programs.

Most public Montessori programs in South Carolina are operated by public school districts. Of the 35 district schools, approximately 18 programs are classified as higher fidelity, 10 programs are classified as mid fidelity, and 7 programs are classified as lower fidelity. Of the ten charter/magnet schools, five programs are higher fidelity, four programs are mid fidelity, and one is lower fidelity.

How long a program has been in place is another program characteristic that was examined. We created three categories. First are well-established programs that had been in place for at least 10 years by the time our study ended in 2016–17 (17 programs, 38% of the total). The second group of programs is established programs that have been in existence for four to nine years (21 programs, 47%). The last type of program are new Montessori programs. These programs had been operating for less than four years, as of 2016–17 (7 programs, 16%). There are stark differences in fidelity levels by age of the program. The older a program is, the greater the likelihood that the program will be considered high fidelity. This could be because as programs become more established, they are better able to focus more resources and attention on ensuring that Montessori is being implemented with fidelity. Alternatively, it is possible that programs that do not exhibit high fidelity do not last as long. On the other end of the spectrum, over 40% percent of all newly created Montessori programs are lower fidelity. Curricular transitions are difficult for administrators, teachers, parents, and students, so it should not be surprising that a significant proportion of new programs are lower fidelity. This finding is not unique to this study, as previous research indicates that challenges with startup charter schools (Sass, 2006; Hanushek et al., 2007). However, young programs can achieve high fidelity. Almost 30% of programs that have been in existence for 1–3 years are high fidelity.

Research Question 3: what types of students have access to high fidelity public Montessori schools in South Carolina?

Previous research indicates that higher fidelity Montessori pedagogy can significantly increase student learning (Lillard, 2012). However, not all public school students have equal access to these programs (Debs, 2019). We found that approximately 42% of public Montessori students attended a high fidelity program, 49% of students attended a mid level fidelity program, and 9% were enrolled in a lower fidelity program. Table 3 shows the fidelity level by the racial and income breakdown of public Montessori students in South Carolina.

Table 3
Fidelity Level by Student Demographics.

		HIGH FIDELITY	MID FIDELITY	LOW FIDELITY	TOTAL
		(N)	(N)	(N)	(N)
# of Students		42%	49%	9%	100%
		(3,024)	(3,542)	(652)	(7,218)
Race	**Black**	42%	42%	16%	100.0%
		(1,012)	(1,024)	(395)	(2,431)
	Hispanic	41%	46%	13%	100.0%
		(184)	(206)	(57)	(447)
	White	41%	54%	5%	100.0%
		(1,620)	(2,133)	(178)	(3,931)
	Other Race	51%	44%	5%	100.0%
		(201)	(175)	(21)	(397)
Low-Income	**Yes**	39%	49%	12%	100.0%
		(1,520)	(1,936)	(466)	(3,922)
	No	46%	49%	6%	100.0%
		(1,503)	(1,605)	(186)	(3,294)

Looking at Table 3, one sees that the proportion of Black, white, and Hispanic students that attend high fidelity programs are quite similar (41–42%). However, Black and Hispanic students are more likely to be enrolled in a low fidelity program than are white students. Students in the other race category are the most likely to attend a high fidelity program; however, this group makes up only 5.5% of the total public Montessori student population.

A concern of many in the Montessori community is that low-income students may not have the same access to high-quality Montessori that high-income students do (Debs, 2019). We looked at the poverty status of students by fidelity level. As seen in Table 3, the plurality of both low-income students and non-low-income students attend programs with medium fidelity, the category with the highest enrollment overall. However, students from low-income families are twice as likely to attend a low fidelity Montessori program (12% vs. 6%).

When looking at other differences, we find that gender and Special Education status do not seem to be related to attending programs with different levels of fidelity. However, there is some evidence that students with English as a Second Language (ESL) status are more likely to be in low fidelity programs (19%) than students without that designation (9%).

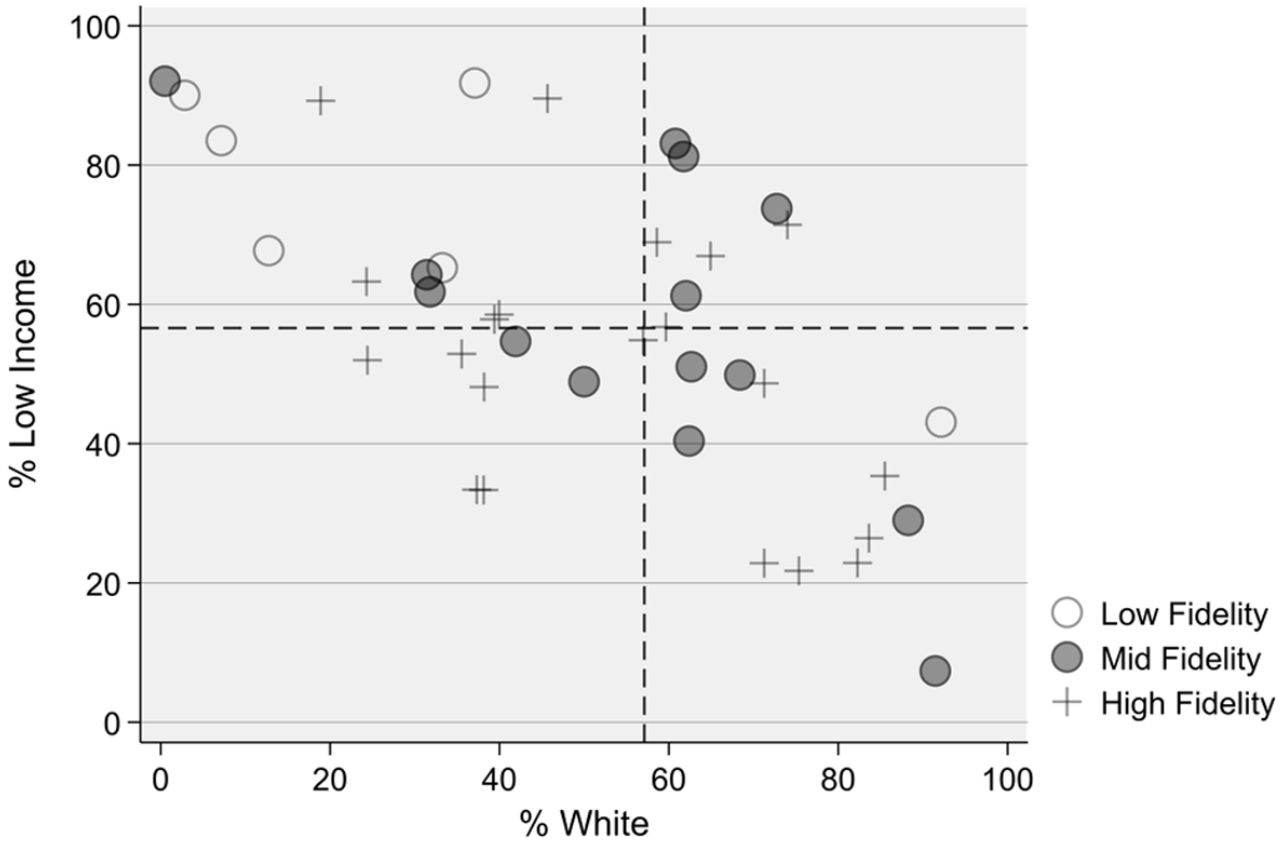
Overall, our analysis found that the vast majority of students are attending Montessori programs with higher or medium levels of fidelity. However, important demographic differences are evident in access to higher fidelity programs. Black and Hispanic students were overrepresented in lower fidelity programs. The same is true of students from low-income families and ESL students. While it is true that the majority of South Carolina's public Montessori students, regardless of race, income, or other factors, attend a Montessori program with at least a medium level of fidelity, significant issues remain regarding access to higher-quality public Montessori programs.

In the preceding analyses, we described student demographics by fidelity level at the student-level. This allowed us to get a sense of the Montessori experiences for public school students in South Carolina; however, from the program-level perspective, the results may be skewed by the fact that some programs have much larger enrollments than others. For the analyses below, we consider student demographics at the program level. This provides a better sense of the average demographics at the program level, but it is important to know that each program is treated the same way in these analyses, regardless of the enrollment in the programs.

Our data allow us to explore the relationship between Title I status as of 2016–17 and fidelity level. Title I schools are high-poverty schools that receive extra funding from the U.S. Department of Education. Twenty-nine of the 45 Montessori programs are in Title I schools. Our analysis reveals meaningful differences. Whereas 75% of non-Title I Montessori schools are classified as high fidelity, only 38% percent of Title I Montessori schools are classified as high fidelity. Further, almost 28% of Title I Montessori schools were characterized as low fidelity, while no non-Title I Montessori school received that designation.

Race and income also are explored in this analysis. Given the well-supported concerns about true access

Figure 3
Poverty and Race by Fidelity Level.



Note: Each symbol represents a public Montessori school. The dashed lines represent the median % low income and % White.

to high fidelity Montessori in the public sector (Debs, 2019), it is very important to examine the relationship between a program's implementation fidelity and its percentages of low-income and white students by program. This analysis is presented in Figure 3.

The dashed lines denote the median percentage of low-income and the median percentage of white Montessori students by program. Using these dashed lines as borders, one can identify four quadrants. The first quadrant in the upper-left-hand corner is for those schools that are above the public Montessori program median in the percentage of students who are low-income and below the median in terms of the white student body. There are thirteen programs in the quadrant. Their fidelity levels are evident by the type of symbol. A significant proportion of these programs are lower fidelity (38%). All but one of the lower fidelity programs are in the quadrant. However, five of the programs in this group (38%) are higher fidelity. Again, educating students from low-income backgrounds may create challenges for administrators and teachers who are in need of additional resources. Nevertheless, higher fidelity Montessori is possible in these situations. The next-most populated quadrant with 13 programs is in the lower right-hand corner. These are the schools with a greater proportion of white students and students from a more economically privileged background. Seven programs in this quadrant are higher fidelity, and five are mid fidelity. This quadrant also includes the only lower fidelity program outside of quadrant one. These results demonstrate that there is no guarantee that programs that have a greater proportion of white students than the average program and fewer low-income students will necessarily provide higher fidelity Montessori.

The remaining programs are in the other two quadrants. The lower left quadrant includes seven schools, five of which are higher-fidelity. This is the largest percentage (71%) of any quadrant. The eight programs in the last quadrant are divided 50/50 into higher- and medium-fidelity. While we find that there

seems to be a program-level relationship between student demographics and fidelity, it is also clear that higher fidelity public Montessori exists in all four quadrants. Student demographics do not fully determine fidelity to the Montessori model.

Conclusion

This paper provides insight into the expansion of Montessori education into the public sector by examining the Montessori environment in South Carolina, a leader in public Montessori education in the United States. Through the analysis of implementation surveys and classroom observations/teacher interview data student record data collected by the state of South Carolina, researchers investigated to what extent public programs in South Carolina were able to implement Montessori education with fidelity to the model, the program characteristics that were related to high levels of Montessori implementation, and which children tended to have access to high fidelity Montessori programs. Findings generally indicated that, despite challenges and tensions created by the education standards and accountability movement, most programs in South Carolina were implementing Montessori with at least a mid level of fidelity. Several characteristics were associated with higher levels of fidelity, including the age of the program. However, findings also indicated that Black, Hispanic, and students from low-income families were disproportionately participating in lower fidelity programs.

Regarding this last finding, researchers previously have examined public Montessori participation by race and income (Culclasure et al., 2018; Debs & Brown, 2017; Debs, 2019). The proportion of students of color and low-income students who participate in South Carolina Montessori programs is similar to state public school averages; however, these students are underrepresented in public Montessori programs when compared to other students in the district (Culclasure et al., 2018; Debs, 2016). These studies have only looked at Montessori participation while ignoring who has access to high fidelity Montessori education. Our study finds that while most students across many demographic categories attend mid or high fidelity Montessori programs, there were inequities. Black and Hispanic students, as well as students from disadvantaged families, were more likely to attend low fidelity programs than were white and higher income students. While previous research indicates that fidelity of implementation is critical to produce more positive student outcomes in Montessori (Lillard, 2012), Montessori school leaders should not overlook the unique contexts in which schools operate. As Debs (2019) notes, it is critical that public Montessori programs consider the needs and preferences of parents and students, especially those from underrepresented backgrounds, when it comes to issues of model fidelity.

Can public Montessori flourish in a standards and accountability world, as is the case in the United States? Schools with an academic focus incongruent with the current accountability movement will face challenges in the public sector. They have to balance adherence to an academic model which is often associated with better student outcomes with the need to adapt and be flexible, which is the key to longevity (Lillard, 2012).[9] Results from our principal survey and teacher interviews indicate that educators indeed are concerned about the number of state and federal mandates and believe that standardized testing requirements raise significant challenges to high fidelity implementation. However, given proper support from district and state officials, most believe that public Montessori can continue to grow and thrive.

While researchers attempted to design a rigorous study with valid and reliable instruments and protocols, there are limitations to this study that must be discussed. A major limitation of this study was the fact that there were no validated instruments at the time of the study to measure implementation program fidelity. Thus, researchers had to create their own tools and protocols, when there was no time or resources to undergo a rigorous validation process. Additionally, it is difficult to classify programs into low, mid, or high level fidelity categories without validated instruments and protocols to create cut-off levels. Another limitation concerns leadership issues as it relates to the principal implementation study results. Our study relied heavily on principals having the knowledge of their school's Montessori program in order to accurately complete the survey. With high rates of principal turnover leading to some principals in schools having little experience with Montessori (Culclasure et al., 2018), it stands to reason that some individuals who completed the survey did not have the deep knowledge about the program to accurately do so. The research team even had principals report that they had no idea how to complete the survey, in which case we asked them to consult with an experienced Montessori teacher or instructional coach. However, this situation likely impacted some of these results.

In this study, we attempted to gauge the possibility of success for the Montessori model in the public sector. In terms of growth and parental demand, it appears

that Montessori can thrive in the public sector. The Montessori curriculum is used in 570 public district and charter schools in the United States. To make it work, school administrators and teachers are trying to meld the Montessori model with the requirements of public schooling in the United States. We find that they have generally been successful, but the fundamental question remains: has the "public school version" of Montessori education positively affected student outcomes? That is a crucial question for public Montessori scholars to answer next and, many researchers, including our research team, currently are engaging in analyses of student academic and behavioral outcomes with a particular emphasis on how these outcomes may differ by level of implementation fidelity. Further, it is critical that researchers do not limit their analyses to the types of outcomes emphasized on standardized tests. Rather, a holistic approach that examines the myriad possible effects that Montessori education can have on children is needed. While many researchers currently are engaging in this work, the fact is that measuring these types of holistic outcomes is extremely difficult. More reliable and valid instruments and protocols need to be tested and made available for researchers to facilitate this process so that these types of critical questions about the impact of Montessori can be answered.

Notes

1. While there are few studies of public Montessori programs (e.g., Brown and Steele 2015; Lillard et al. 2017; Debs 2019; Snyder et al. 2022)there are a variety of early education models and curricula aimed at promoting young children's pre-academic, social, and behavioral skills. This study, using data from the Miami School Readiness Project (Winsler et al., 2008, 2012), the research on private Montessori programs is not much more extensive. See Lillard (2016, Chapter 11) for a summary of recent research.
2. Magnet schools are public schools of choice meant to increase voluntary racial integration. Charter schools are public schools of choice that trade more autonomy from state and local regulations for increased accountability via renewable charters or contracts. Magnet and charter schools often have a curricular theme (e.g., STEM, arts, or Montessori).
3. There are a number of competing Montessori organizations through which a Montessori school can be affiliated. The history of these organizations is rife with internal politics and competition in the United States. Any school is free to identify themselves as "Montessori," as the name is not protected by copyright or patent (Whitescarver and Cossentino 2008, 2592).
4. Before instruments and scoring rubrics were considered final, they underwent an extensive review by the project's Montessori consultant, as well as leaders from numerous national and statewide Montessori organizations, including the American Montessori Society (AMS) and the National Center for Montessori in the Public Sector (NCMPS).
5. The number of Montessori programs included in surveys (N = 53) is larger than sample size used for classroom observations (N = 45). This is because some programs merged or discontinued programming before observations. Further, we used the implementation survey results to learn that some Montessori programs did not meet the minimum threshold for Montessori fidelity, so were excluded from the classroom observation analysis.
6. We had one classroom observation for every 4 classrooms at each grade level. For example, if a program had three early elementary classrooms, we would randomly visit one of them, for programs with 8 early elementary classrooms would visit two, and there would be three classroom observations if a program had 10 Montessori early elementary classrooms.
7. The South Carolina Department of Education uses the PowerSchool database to aggregate student-level demographic information, test score data, and behavioral outcomes information. Student-level data was requested by researchers and provided after an approval process.
8. For four programs, we are unable to examine student-level demographic factors, as we were unable to identify which students participated in the Montessori program in the database.
9. This challenge may be particularly significant for the approximately 5% of charter schools that are converted private schools (Center for Education Reform 2014).

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Competing Interests

The authors have no competing interests to declare.

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Acknowledging Montessori Education — a Research Perspective of Montessori's *Legacy for the Future*

Symposium Report

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Keywords: *Cognition, Education for sustainability and global citizenship, Inter-war era, Learning to learn, Maria Montessori, Montessori Education, Preschool children, Research methodology, Disadvantaged preschoolers*

Abstract: On 6 May 2022, 70 years after Maria Montessori's death, Stockholm University and the Department of Education and Didactics organized an international Montessori symposium. The idea was to present a breadth of research on Maria Montessori.

The symposium dealt with Maria Montessori in the interwar period, an analysis of the history of ideas. Another presentation suggested possible research models to study this large field. The symposium also presented interpretations of Montessori's writings that point her out as a visionary and pioneer in education for a sustainable world. An additional research area addressed was the potential of neuroscience to examine the effects of teaching theory and learning in Montessori education. Finally, this report describes a study on whether Montessori-inspired education compared to traditional education stands up in areas of socio-economic disadvantage.

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Montessori: A public intellectual of the Inter-War Era

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My research situates the multifaceted movement surrounding Montessori, within the wider public debate context of the interwar years, with a focus on the intersections between science, politics and educational ideas (Quarfood, 2022).

As a public intellectual and movement leader, Montessori aimed at more than just a reform of teaching methods. Addressing far-reaching questions about children's place in society, her movement challenged established notions about childhood, parenting and schooling.

I will here highlight some aspects of the Montessori movement's message about the child's liberation, and how this message was received in the British and Italian cultural milieus, two countries in which the movement had a great impact. The press was helpful in establishing Montessori's image as an "educational wonder-worker". Her Casa dei bambini experiment, initiated in 1907, was presented as a unique event, a discovery of the hidden potential of preschool children. It seemed to confirm Ellen Key's vision of the 20th century as the century of the child. In the press debate it happened more than once that Montessori's educational ideas were labelled as an –ism. Articles referred to Montessorism, as one referred to feminism or Freudianism. The term Montessorism designated the wider world view, social agenda and spirit of Montessori education. Central to this world view was the idea that the child was oppressed and had to be liberated. This belief, that the liberation of the child would pave the way for a new and better world, contrasted in its suggestive ambiguity with the rigorous method offered by the movement. While there were clear instructions for the proper use of the didactic materials and the preparation of the school environment, the movement's vision of the liberated child – the very heart of the method program – was less clear. What exactly did the child have to be liberated from, and what was the ultimate purpose of this liberation?

A key concept of Montessorism was liberty, understood as biological liberty. It was a question of respecting the child's freedom to develop its psychophysical potential at its own pace, without adults interfering too much in this natural growth process. Ellen Key, like Montessori an adept of evolutionary biology of the Spencerian kind, believed that only free play could stimulate personality development at the preschool stage. Montessori dismissed this laissez faire view. Liberty and discipline were two sides of the same coin. Spiritual energies could only be liberated in a structured learning environment offering opportunities for self-development.

Thus the Montessorian concept of liberty was linked to ideas about self-discipline through auto-education. To make the child independent was the supreme goal. To paraphrase Virgina Woolf's famous essay of 1928, the fundamental precondition of emancipation was to acquire a room of one's own. Montessori had a vision of her Casa dei bambini as a place where adult power and authority was suspended, a kind of free-zone allowing children to take command of their own learning process.

British sympathizers found it difficult to really grasp this vision. At first, they tended to interpret the Montessorian principle of liberty as corresponding to the pluralistic views of classical liberalism, where freedom of choice was central. A liberal preschool education, they believed, ought to offer a variety of stimulating educational tools, like the hors-d'oeuvres of a Swedish smorgasbord, for the children to pick and choose from. In Montessori's view, such eclecticism would lead to confusion, mental indigestion. The child's liberation could only be achieved in a life space where everything was arranged to further the development of autonomy. As Montessori claimed in a London lecture in 1921, it was necessary to create for the child "a better world than that which commonly existed around him". This captures in a nutshell Montessori's whole project: to develop real independence the child needed a room of its own. While liberals had welcomed preschools as a complement to family upbringing, and conservatives had feared that preschools would undermine parental authority, Montessori presented her preschools as a place where children could be liberated from the pressures imposed by the adult world.

In the mid-1920s Montessori radicalised her critique, denouncing "adultism" as a tyrannic ideology making everything revolve around the needs of adults, while depriving children of agency. The tensions between the generations, between adults and children, were now described as a regular war. This radical critique was inspired by the psychodynamic theories in vogue. In Das Kind in der Familie, 1923, Montessori developed ideas about the birth trauma and about the child's subconscious defense mechanisms, as a reaction to parental pressure. The Oedipal conflict was however absent from her description of the child's psyche. She felt free to combine Freudian ideas with theosophical notions, assuming a spiritual life force – the psychical embryo – in the depth of the child's soul.

This also led to a reinterpretation of the Catholic concept of original sin. It applied to adults rather than children, Montessori claimed in the Italian journal L'Idea Montessori. It is the adult that must change and not the child, she declared at the 1930 International teacher training course in Rome.

It is indeed a paradox that the Montessorian critique of adultism was radicalised during the decade when her movement received support from the Mussolini regime. How was it at all possible to deliver such a sharp critique of authoritarian education in a totalitarian society, where dictatorship had been installed in 1926? As is clear from archive material, for instance the fascist secret police files on Montessori, the fascists wanted to appropriate Montessori education for their own ends, as a means of gaining control over the new generations. A "Montessorism without Montessori" as the spy reports put it, could be a powerful disciplinary tool. Furthermore, the critique of adultism could be reframed as a dismissal of parental authority, in order to subordinate the child to totalitarian state authority.

This was of course a complete distortion of Montessori's culture-critical message. In her denunciation of militaristic education, delivered at the disarmament conference in Geneva in 1932, Montessori claimed that the age-related power conflict was the root conflict of society, with criminality, war and oppression in its wake: "the first war among people is the war between parents and children, between teachers and pupils." As she explained at the Montessori Congress in Rome, 1934, the child had to be liberated from too close bonds to adult authority persons. To be forced to bow to a stronger will was the "real danger". A fascist spy described this message as "super anarchistic and in absolute contradiction to fascist objectives."

A research methodology as an ideology – towards understanding Montessori education through empirical projects' meta-analysis

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Introduction

A few decades ago, Jurgen Habermas (1972) described *three interests* that constitute scientific reasoning. His claim was that various forms of scientific inquiry might be based on implicit modes of thinking that he called *interests*. Another thinker, Pierre Bourdieu (1988) coined the metaphor of *domesticating the exotic* and *exoticizing the domesticated* when referring to the research activities performed by scholars who aim to describe the culture of the Other or/and especially the culture that they are part of. These two threads of thought lead to the conclusion that the way in which scientific research is done might be interesting on two levels.

The first level relates to *the results of research* as we (as a community of researchers) long to understand more, we appreciate verifying hypotheses. In this case, we first make sure that the research we are interested in meets the criteria of methodological and conceptual accuracy. Having agreed that the methodological foundations of a given project are correct, we turn our attention to the results. This level of research analysis is absolutely necessary and quite obvious, if we wish to construct knowledge, as it is always a communal effort. We are able to go forward, search deeper, analyze marginalized issues and topics, only if we are familiar with the work of our colleagues.

There is, however, the second level of research analysis directly based on the aforementioned thinkers and their claims on scientific reasoning. For instance, by investigating the research methodologies implemented in research on Montessori education one can make an attempt to describe what interest(s) lie(s) behind the project and therefore what logic of education is "at work" there as well as – after Bourdieu – it becomes possible to check whether the scholars use the strategy of *domesticating the exotic* or *exoticizing the domestic*. This choice (regardless of whether intentional or not) may have significant social and intellectual consequences. If so, then the logic of scientific production should be investigated and the outcomes of such critical insights may bring about the insights potentially demasking presumptions of academic research reasoning.

Cognitive interests and epistemic strategies

According to Jurgen Habermas scientific or academic reasoning, thought and research are based on cognitive interests. These interests can be explicit motives or/and implicit conditions in which knowledge is constructed. Furthermore, it is possible to distinguish between three different interests and hence also methodologies corresponding with them. The technical interest is analytically oriented and longs for objectivism. This form of (neo) positivist implements mainly quantitative strategies, often incorporating advanced statistical aggregations of data. Habermas reckons that the aim of this interest is verification of existing or new hypotheses and practices. This

form of verification leads to the control and management of processes. For instance, we might be interested to check if the "Montessori approach works". Positive or negative verification of such a hypothesis (of course restricted to some variables) will potentially result in sustaining or rejecting some educational practices.

The second interest that Habermas called *practical* is focused on the investigation of intersubjective and shared meanings and therefore is usually qualitative both on the level of research strategy but also on the level of the type of data gathered. The main aim in this kind of scientific reasoning relates to exploration and understanding some aspect of reality and practice. Here we can find approaches such as: (auto)ethnograpy, grounded theory approach or phenomenography and others. A researcher interested in Montessori education following this path could, for instance, propose a categorization of various interpretations of a given phenomenon.

The third interest is critically oriented, and Habermas calls it *emancipatory*. Here we find critical research strategies, based on critical theories (for example – but not necessarily – Frankfurt school, feminism, Freireian inspired etc.). The main aim here is the emancipation from limits, empowerment, questioning well-established dogmas and engagement in critical insights into the cultural and social construction of human society.

In the *Homo Academicus* (1988) Bourdieu pointed out that the academic world of sociology is dominated by the epistemic strategy that he called *domesticating the exotic*. It relates to the belief that the researchers are "in possession" of adequate language, categories and tools to the describe the culture of the Other. On the methodological level it may mean the attachment to surveys with close-ended questions or various tests, quasi-medical examinations and so on.

The opposite strategy is connected with the attitude and approach that Bourdieu in other works called reflective sociology. In such a strategy it is the questioning of well-established patterns of our own thought (and thus radical humbleness) that is essential. It is also necessary to negotiate the meanings with those who become the subject of our research project since their perspective is indispensable to creating any forms of research results. In other words, the researcher needs to accept the fact that they do not possess the language that can adequately describe the *other* – which of course questions the whole idea of post-enlightenment science and academic research as the most ideal language to "grasp" the complexity of our world (Diagram 2).

The method

The research questions of the analysis summarized in this text relate to cognitive interests and the two strategies outlined above. As a result, four questions were formulated, and they are as follows:

1. Which cognitive interests are present in research projects related to Montessori education?
2. Which cognitive interests (if any) are less popular or marginal?
3. Which of the two strategies are present in research projects related to Montessori education?
4. How can the results of such meta-analysis be interpreted?

The differentiating criteria taken into consideration included:

1. research strategy – qualitative, quantitative, mixed, conceptual;
2. data-gathering technique – surveys/polls, tests, secondary data, interviews, observations, other;
3. research sampling scheme – randomized, intentional (non-randomised), *ad libitum*;
4. sample population – children/students, teachers, parents, school administrators, other
5. forms of conclusions – idiographic, nomothetic, none or no-data

The research sampling incorporated in the presented meta-analysis can be described as non-randomized, purposeful and it included 174 research reports published between 2000 – 2020 that are accessible on the Web of Science Clarivate data base and include Montessori as one of the keywords.

Results

In this summary only a few results are presented due to the word count limit and they are all simple, quantitative observations. They should be treated as snapshots rather than full presentation of the research results.

First of all, there is a fairly steadily growing trend of both publications and citations of articles relating to Montessori education, in the second decade of the twenty-first century (2010 – 6 articles, 2011 – 10, 2012 – 18; 2013 – 9; 2014 – 10, 2015 – 10, 2016 – 13, 2017 – 13, 2018 – 14; 2019 – 20, 2020 – 22). This trend is even clearer when it comes to citations between 2005

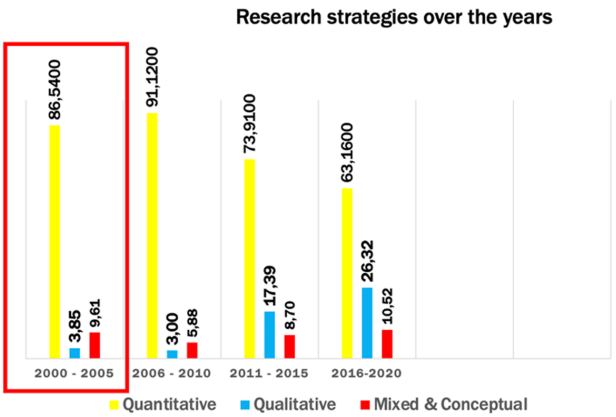

Diagram 1

Research strategies in Montessori related articles in 2000 – 2020. Source: Own research.

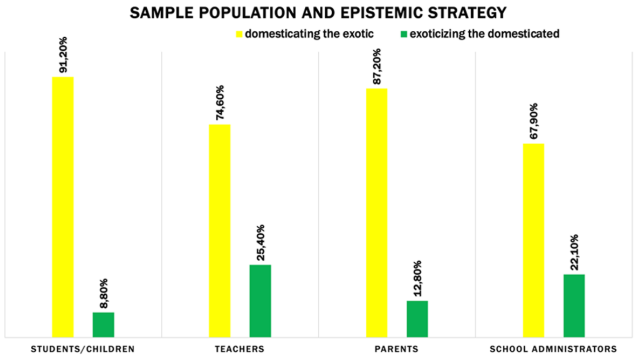

Diagram 2

Sample population and epistemic strategy. Source: Own research.

and 2020. The shift in the research strategies (in five-year intervals) shows that with time the research become more diverse (see Diagram 1).

The first five years shown in the diagram (marked with the red rectangle) cannot be treated as fully justified due to the limited number of articles, but the next three other intervals show that we can talk about growing diversity in the implemented methodologies and thus cognitive interests. Nevertheless, the dominance of quantitative strategy is unquestionable.

This claim above is also clear if we take into consideration the criterion of data-gathering techniques. In all the analyzed articles surveys occur most often (104 times), the tests – 16 times, secondary data – 17. Interviews (usually individual in-depth) were present 31 times, and observations – 16. The number of all identified data-gathering techniques equals 192, which means that in the case of at least 18 reports the researchers decided to use at least two techniques.

When it comes to the form of conclusions within the subgroup of research characterized by quantitative strategy, 56.8 % of them belong to idiographic reasoning with 39.5% to nomothetic (in 3.7% cases there were no conclusions to identify). Within the subgroup of qualitative research almost eighty percent of reports expressed conclusions in an idiographic manner (13.8% – nomothetic, 6.9% – no conclusions).

One of the analytical observations included combining the epistemic strategies defined by Bourdieu and the sample population.

As we can see *domesticating the exotic* is dominant regardless of the sample population, however this image becomes more diverse when the teachers and school administrators are examined. The children – although Montessori is a child-centered pedagogy (Diagram 2) – very rarely participate actively in the research processes.

There are probably a few possible interpretations. One of them might relate to highly prestigious journals' policies, possibly discouraging researchers to submit articles that are not objective, reliable (in the traditional meaning of this word) or limited to small, non- representative samples.

Closing remark

In this project I am not opting for any specific cognitive interest or epistemic strategy. In research, as in the natural world, diversity is the key word. The community of people interested scientifically in education needs various approaches, diverse languages and (auto)critical insights. Seeking for the truth (however conceiv) demands asking difficult questions, even if the global tendencies are different.

Montessori pedagogy – Sustainability and Global citizenship

Eva-Maria Tebano Ahlquist, Ph.D. and Per Gynther, Ph.D., Stockholm University

In 2018, the OECD launched the project *Future of Education and Skills 2030* with the aim of "helping countries find answers to two far-reaching questions: what knowledge, skills, attitudes, and values will today's learners need to thrive and shape their world, and how can education systems develop these competencies effective-

ly?". (OECD, 2018, p. 2). We, therefore, have examined whether Maria Montessori has formulated answers to these questions in her writings. However, the aim of the study is limited *to understanding how Montessori education, according to Maria Montessori, will enable 6–12-year olds to meet future challenges, implying to care for and contribute to the wellbeing of society and the planet as a whole*.

The study is based on qualitative content analysis, and a didactic perspective is implemented by interpreting Montessori's descriptions and integrating the practical application described in the Montessori training courses we attended. The data interpreted consists of the three books; *To Educate the Human Potential, The Child, Society and the World*, and *From Childhood to Adolescence*. All three deal partly or exclusively with children in primary and middle school. In addition, two chapters from the book *What You Should Know About Your Child* have been included. Although this book deals with the preschool age, some aspects of its didactic application are also essential for later school ages.

Montessori consistently addresses education issues for sustainable development and global citizenship in these texts, often in relatively straightforward terms. Overwhelmingly, she has a theme directed toward the adult that humanity must form "a universally harmonious society" (1989a, p. 110) to meet and manage the world's challenges. If this concept of universality is to be truly realized, it must be achieved, according to Montessori, "through a 'direct preparation' of the new generation, that is, through education" (1989a, p. 110). She stresses the need to cultivate a "universal consciousness", which means a way of understanding the world with all its interrelationships, including humanity. Humans need to become aware of their part of this unity, which implies a specific responsibility. However, she claims that this understanding has not been brought to life by schools. Instead, it has "been realized more in terms of a threat of destruction" (Montessori, 1989a, p. 109). Unity implies that each individual is part of global citizenship, as we all have a relationship with the world. Therefore, teachers have a mission as agents of change as this approach and understanding are cultivated during children's upbringing. Owing to the child's specific developmental characteristics and needs, Montessori argues that the age between six and twelve are susceptible to this understanding. The child has developed abstract thinking and has an imagination that enables them to travel "through time and space" (1994).

However, Montessori accentuates the importance of nourishing children's imagination to support these characteristics. The teacher has a responsibility to acquire a deep knowledge of the subject that can go beyond the requirements of the curriculum to engage children's imaginations. The latter is crucial for creating the conditions for emotional bonds to the content treated. Montessori (1989b) stresses that teachers must have children's ability to imagine and visualize and therefore portrays historical events characterized as imaginative stories. She underlines that such an approach is essential for them to engage emotionally and intellectually with the content.

Moreover, Montessori's emphasis on using children's imaginative capacities demonstrates a desire to fully engage children in dialogues about how different ways of life are related to sustainability issues. In such dialogues, children develop an awareness of the importance of work that benefits others, and they will experience the value of the work of different actors. However, the value of different actors' work is not always only based on factual knowledge but also on personal interests, which sometimes can conflict with each other. Montessori's view on how teaching is supposed to be conducted will therefore create conditions for children to experience the importance of negotiating to reach solutions that can be considered reasonable and morally acceptable. Therefore, we interpret Montessori's intention that teaching must involve activities where the teacher and the children critically examine the ideas and interests behind them, rather than promoting a specific view on such issues.

When Montessori (1989b) points out that children between the ages of 6 and 12 begin to reflect on metaphysical questions such as "What am I and what is the task of mankind?" she implies that these questions should be addressed at two levels: a human species level and an individual level. She reinforces the need for a global perspective in each individual's lifelong search for answers to these questions. However, according to Montessori (1989b), such a search must be grounded in an awareness that the human condition results from the Earth's 4.5 billion years of evolution. Therefore, it is not sufficient for history teaching to only study human history. The subject of history, traditionally seen as social science, thus becomes natural science as well. According to Montessori (1989b), it is necessary to understand the interrelationship between these disciplinary fields and understand that the world is not divided into subjects; instead, the intention is to get an idea of the world as a holistic whole. Therefore, the subject of history is introduced with the creation of the universe, which must be presented in a specific way. Montessori (1989b) describes it in the following words: "To interest the children in the universe,

we must not begin by giving them elementary facts about it, to make them merely understand its mechanism, but start with far loftier notions of a philosophical nature, put in an acceptable manner, suited to the child's psychology" (p. 19). By the words "of a philosophical nature," it is clear that it is not primarily a matter of learning facts about the universe's history. What is crucial in this way of thinking is not to separate the history of man from the history of the universe and the Earth but rather to see them as united.

The history curriculum continues with the evolution of the Earth, followed by the study of life, including early humans to Homo sapiens, and the study of civilizations. This chronological example of history enables the child to orient in time and space. Children's perspective on historical time is a critical aspect of Montessori education and at the forefront of Montessori's didactic application (Ahlquist & Gustafsson, Gynther, 2018). In order to comprehend thousands and even millions of years, an understanding of high numbers is required. In fact, the subject of mathematics already deals with high numbers in preschool, where children can perform counting operations with thousands using concrete materials. Montessori explains, *"Perhaps the child is likely to be most impressed by size, and the tremendous extent and magnitude of life on the globe may easily be introduced, because he already has in his possession the power of numbers"* (Montessori, 1989b, p. 20). This highlights how Montessori breaks with the way the task of schooling has traditionally been treated and how subjects have traditionally been presented and illustrates Montessori's idea of meaning-making aspects of teaching.

By placing the history of humanity in relation to the history of the universe, the creation of the Earth, and the evolution of life, Montessori goes beyond humanity's narrow and provincial boundaries. Therefore, Montessori's history curriculum must be seen as an expression of her desire to cultivate global citizenship. However, the content of Montessori education is not primarily about wars and rulers but about the everyday lives of people and the legacy of each civilization's achievements. Montessori (1989b) stresses the importance of allowing children to study and visualize history in order to "help the child to realize the part that humanity has played and still has to play because such realization leads to an uplift of soul and conscience" (Montessori, 1989b, p. 55). Obviously, the aim is not primarily to have the child memorize facts about different civilizations or historical epochs. Instead, the primary purpose emerges when we consider Montessori's quest to cultivate a universal consciousness in children: to visualize that human needs are identical, no matter where or when people have lived.

If we refer back to OECD's two far-reaching questions, Montessori highlights crucial knowledge that needs to be acquired by the child. However, this knowledge is meaningless if it cannot be used appropriately. Therefore, skills, meaning the ability to use knowledge appropriately and effectively, play a central role in Montessori's view on teaching. According to Montessori, schools must involve the whole person in learning, including a "spiritual" and philosophical dimension. If these objectives are considered, they can positively guide human behaviour. As we interpret Montessori, the goal is that education should result in values that enable people to take a stand on ethical and moral issues. Therefore, teaching must approach what Öhman describes as a pluralistic tradition characterized by "a striving to promote different perspectives, opinions and values when dealing with various issues and problems concerning the future of our world" (Öhman, 2008, p. 20). In addition, Montessori emphasizes the importance of letting children experience reality and not just read about facts. She states that "[t]here is no description, no image in any book that is capable of replacing the sight of real trees, and all the life to be found around them, in a real forest. Something emanates from those trees which speaks to the soul, something no book, no museum is capable of giving" (Montessori, 1994, p. 19). Our reading and interpretation of Montessori's writings show essential prerequisites in Montessori education to develop a sustainable society and global citizenship and encompass all subjects and activities from preschool onwards.

When helping is compromising: A perspective on learning how to learn across development

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What is the goal of every living species? To be autonomous! Autonomy is the best insurance for the durability of any living species. Thus, the genetic program encodes the information necessary to learn self-management skills across the development (Posner & Rothbart, 2007). As this program unfolds, interactions with the environment, called life experiences, are crucial and shape 'mental habits'. As adults, our reactions are mainly the results of our childhood history. It is time that new 'habits of mind' emerge, given all the challenges we face at the societal, environmental, health, and professional levels. New mindsets are crucially needed to address them.

Mindsets and habits of mind are shaped across development. As everything cannot be learned at once, biological logic allows the child to successfully develop their self-monitoring (self-management) skills thanks to gene expression. First, the child acquires skills to evolve and function in their physical environment: self-control of body and senses (i.e., sensorimotor skills) (**Pos**ner, Rothbart, Sheese, & Tang, 2007). The child confronts limits and physical constraints and adjusts to them: hitting a wall hurts, so the child modifies their strength, speed, and movement accordingly. Children sharpen and refine their senses and lose at the same time their ability to hear all speech sounds, in favor of their mother tongue (Leroy et al., 2011; Pinel et al., 2015; Werker & Hensch, 2015). Thus, while reducing possibilities, there is a gain in efficiency of signal processing (i.e., information from the 'outside world'). This is the slow and natural selection process of specialization: the child adapts to what is needed to live. Thus we speak about the 'cognitive cascade' (Denervaud, Gentaz, Matusz, & Murray, 2020; Rose, Feldman, Jankowski, & Van Rossem, 2008). The first skills greatly influence the acquisition of the following ones. If young children do not 'calibrate' themselves correctly, they will function with an 'erroneous' or 'limited' toolbox for the rest of their learning skills. We could take the image of a box of crayons. If a young child acquires many pencils and learns to sharpen them when needed, they will be able to create a precise drawing later on. On the other hand, a child whose palette is reduced to primary colours without sharpernerss will have a limited vision and possibility of creation with basic tools. Without over-stimulating the young child, the first years are crucial in developing their sensory and motor toolbox.

From the age of 6, the child will progressively develop their ability to learn 'how to think': the management and control of their errors to achieve success. It is the emergence of reasoning; through errors and trials, their own and those of others. Errors are unexpected events that naturally trigger a reaction of slowing down (Danielmeier & Ullsperger, 2011; Ullsperger, Danielmeier, & Jocham, 2014; Ullsperger, Fischer, Nigbur, & Endrass, 2014). We stop to integrate information and adjust. It is even more true in elementary children, as the brain is highly plastic for that skill (Denervaud et al., preprint). Plasticity means that after any event that was not planned, the child will 'print' following feedback as means to adapt at the neural level. What the child experiences daily, such as at school, will create connections that will be reinforced during repeated experiences to finally result in what we call the automatic or spontaneous reactions of adults.

Using neuroscientific and behavioural approaches, we compared students from Montessori schools (i.e., child-centered with self-directed curricula where children are mixed with peers of different age ranges) with students from so-called traditional schools (i.e., teacher-centered with the delivery of instruction where children are regrouped with peers of a similar age range). Based on different schooling experiences, how do children shape their reactions to mistakes? How do they adjust to errors? How do they perceive their social environment? How does this influence their creative and independent thinking?

We show that Montessori students, compared to students from traditional schools, learn earlier to detect their mistakes while taking the time to self-correct. As a result, the older they get, the less they are distressed and slowed down by getting things wrong. and self-correct spontaneously (Denervaud, Knebel, Immordino-Yang, & Hagmann, 2020). Also, after an unexpected event such as a mistake or an improbable success, our brain becomes very permeable to information to be 'learned'; it creates new connections to adapt. In this phase, the quality of the feedback is crucial. If at this time, an external value judgment or an extrinsic reward is given, the brain associates the resolution of the problem with external help. This is what I would call 'the third hand'. Indeed, let us take the example of a young child who is learning to walk. Toddlers must adjust their center of gravity together with their center of mass to achieve balance. Indeed, walking is a perpetual imbalance, we must constantly readjust balance. Children will therefore use their senses to integrate feedback from these successive imbalances and adjust their body for bearings. Falling is part of the process, and so are the first successes. In these crucial moments, if the caring adult, because of impatience or willingness to help, reaches out or holds the young child's hand when making some steps, the young child integrates this extrinsic cue as a necessity for success. The child makes biased connections: external help is needed to achieve balance! If repeated too often, this experience may limit the autonomy of movements, as their brain has integrated outside help as necessary. What to do when this 'third hand' is not there? Maybe stop, or maybe wait for other help… These may be the less adventurous or agile children later in exploring the physical world on their own. The same is true for thinking; any outside help or judgment will then be integrated as a 'pillar' necessary to succeed; the child will no longer be in their autonomy and ability to succeed but

dependent on this 'third hand' (e.g., a reward, appraisal, compliment, punishment) to make most mental moves.

Congruently, we observe that for Montessori students doing wrong or right is neither 'bad' nor 'good'; there is no connotation of value (i.e., judgment) about their actions. They stick to the facts (e.g., 'it is still not correct, I need to try more). Conversely, students in traditional schools strongly associate the action of doing right with a positive value judgment (e.g., 'it is good that I do correct') (Denervaud, Hess, Sander, & Pourtois, 2021). While we may think this is an excellent bias to have, the child will have at heart to do correct, there is a counter effect. Indeed, adults have the opposite reaction; doing wrong is experienced as something very negative (i.e., the symmetry effect) (Aarts, De Houwer, & Pourtois, 2012, 2013). Consequently, we try to avoid mistakes and aim, for the most part, at the 'correct' answers only. This behaviour prevents creative, explorative, and cooperative behaviours. Logically, we observe that where Montessori students create neural connections to solve problems, traditional school students wire their brains to memorize the correct answers (Denervaud, Fornari, et al., 2020). In the short term, the behavioural differences may be minimal, but traditional school students may limit themselves in the long term. Indeed, aiming for the right answer is aiming for a fixed goal, not a process and the pleasure of the journey to an adjusted goal.

The social context also influences our relation to errors. As long as the context is one of collaboration and cooperation, we learn as much from our mistakes as from others. However, if the context is competitive, this learning is greatly diminished because we no longer share a common goal. Montessori students evolve in a peer-to-peer learning environment, within multi-age classrooms where social comparison is minimal and without grades (i.e., adult-based value judgments like grades, praises, or rewards), which is not the case in traditional Swiss environments. In assessing their emotional recognition skills, we observed that students in traditional schools perceived their social environment as a threat.

In conclusion, we observed that while the brain grows the faculty of learning how to learn, the children will modulate their skill according to their daily training with the errors and successes at school: the brain 'shapes' in response to experience. If it is focused on memorizing the correct answers, avoiding mistakes as much as possible, making quantitative judgments, and competing, then neural connections and behaviours will reflect that. Knowing that, as adults, we are the result of our history and, for the most part, afraid of getting it wrong and feeling threatened by others if we fail, it seems urgent to re-think elementary pedagogy. Indeed, these consequences have a broader impact on our ability to adapt. If we are afraid of making mistakes, we are afraid to think outside the box! This fear affects our flexibility and creative thinking abilities. Montessori students' creativity grows stronger as they age and will even be the key to their academic success. They will not do well in school because they perform better, but because they understand, think and adapt (Denervaud, Knebel, Hagmann, & Gentaz, 2019). It will also influence their critical thinking abilities: they are less subject to group-thinking, doing for doing's sake, or acting because the adult said so (Décaillet, Frick, Lince, Gruber, & Denervaud, submitted).

The Montessori environment allows children to embody knowledge and become masters of their thinking, to be autonomous and open to the thinking of others who are not perceived as a threat but as co-actors. In the current context and given the social problems we face, it is interesting to ask whether a fundamental root of the problem does not come from the students' school experiences. At present, social experiences are quite abnormal in that they do not reflect real life: children are isolated by age, forced to do the same, activity and given work at the same time in a restricted time window. While their brains should be dealing with diversity, we skew reality to a standardized experience. Instead of gaining flexibility (Denervaud, Christensen, Kenett, & Beaty, 2021), the brain becomes rigid regarding unpredictable events and social experiences. Because of the significant challenges of the century, it seems urgent to consider this new knowledge to adjust educational practices so that a greater number of children develop a healthy relationship with error and with others, to let their autonomy and capacity to think and act for their future.

The impact of Montessori education on the cognitive, social and academic development of disadvantaged preschoolers

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In my lecture, I presented a pre-registered and published study (Courtier et al., 2021) in which we compared the language, math, executive, social skills and well-being of disadvantaged preschoolers. Participants were randomly assigned to either conventional or Montessori classrooms in a French public school, with the latter being adapted to French public education. To help understand how the curriculum evaluated here differed from what

could be considered a high-fidelity Montessori curriculum (Lillard, 2012) we developed an openly available scale. measuring the fidelity of implementation of the Montessori curriculum in the public preschool. These adaptations included fewer materials, shorter work periods, and relatively limited Montessori teacher training.

The study consisted of two experiments, and data were collected over 4 years. In the cross-sectional experiment, we compared the effect of the curriculum on the performance of three groups of kindergarteners, i.e. the Montessori-public group, the conventional-public group and a Montessori-private group from an accredited Montessori school ($N = 176$; $M_{age} = 5–6$).[1] In the longitudinal experiment, we followed and compared the progress of the children within the public school over the three years of preschool ($N = 70$; $M_{age} = 3–6$). Both analyses showed no difference between the adapted Montessori curriculum and the conventional curriculum on math, executive functions and social skills. However, disadvantaged kindergarteners from Montessori classrooms outperformed their peers from conventional classes and had comparable performance to that of the advantaged children from the accredited Montessori preschool in reading. Also, children following the adapted Montessori curriculum were aware of their reading competence and reported feeling as competent as children from the Montessori private preschool. Thus, literacy appears to be one domain where Montessori preschool education may have the potential to reduce early socio-economic inequalities.

Because Montessori's approach to learning is quite different from conventional pedagogy, it is possible that general characteristics have made it easier for students in these classes to access reading. However, it is difficult to explain why they would not also influence other areas of learning (e.g., mathematics learning). The advantage of the Montessori approach to reading is then most likely explained by its specific method and materials for literacy acquisition. Furthermore, the lack of difference in other learning areas indicates that this advantage does not reflect an over-investment in reading at the expense of other skills. Three hypotheses can be formulated. First, from the age of three, children systematically learn the correspondences between phonemes and graphemes (e.g., with the sandpaper letters). This method, called synthetic phonics, has been shown to be particularly effective for learning to read (Castles et al., 2018). Second, the Montessori curriculum allows children to generate words by themselves (e.g., with the movable alphabet materials), which also emphasizes learning the sounds of words and may promote their memorization (Bertsch et al., 2007). Third, the Montessori materials address learning through touch and manipulation. Combining the haptic modality with visual and auditory modalities has been shown to promote reading learning (Bara et al., 2004, 2007). Our results may thus generalize previous methodologically less rigorous studies that showed a similar early reading advantage in preschoolers from variable socio-economic backgrounds in the United States (e.g., Lillard, 2012; Lillard & Else-Quest, 2006).

Notes

N Number of participants, *M* age group.

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Competing Interests

The authors have no competing interests to declare.

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