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Table of Contents

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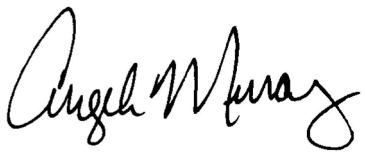
From the editor:

Featuring work from some of the most respected names in Montessori research, this issue of the *Journal of Montessori Research* represents a major contribution to the field and provides valuable resources for researchers—from both inside and outside the community—who are interested in examining Montessori education. The issue begins with an extensive examination of the historical foundations for Montessori education, continues with a comprehensive model of the inputs, actions, goals, and outcomes of Montessori programs today, and concludes with a psychometric analysis of tools designed to account for variability in the implementation of Montessori instructional practices in future rigorous research.

I also am pleased to inform readers about another important development in Montessori research. A Montessori Special Interest Group (SIG) now exists within the American Educational Research Association (AERA). Founded in 1917, AERA is "the largest national interdisciplinary research association devoted to the scientific study of education and learning." Montessori education's presence in this organization shows important progress in the recognition of Montessori research within the broader field of education scholarship. I encourage you to join the SIG today, for only $5 for AERA members, to support continued progress along this path.

Sincerely,



Angela K. Murray, PhD
Editor, *Journal of Montessori Research*
Director, Center for Montessori Research
akmurray@ku.edu

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Authentic Montessori: The Dottoressa's View at the End of Her Life Part I: The Environment

Angeline S. Lillard[1] and Virginia McHugh[2]

[1]University of Virginia
[2]Association Montessori International (AMI) / USA

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Keywords: *childhood education, Montessori, alternative education, school curricula, school environment*

Abstract: Maria Montessori developed a form of education in the first half of the last century that came to be called by her surname, and research indicates it often has positive outcomes. In the years since its development, tens of thousands of schools worldwide have called their programs *Montessori*, yet implementations vary widely, leading to confusion about what Montessori education is. Although there are varied opinions, here we use Dr. Montessori's books and transcribed lectures to describe the conclusions of her work at her life's end. We term this final conclusion *authentic* in the sense of "done in the traditional or original way," (the primary definition of the adjective in *Oxford English Dictionary*, 2019). We do not claim that the original is superior to variants; this is an issue for empirical science. Our overarching goal is to provide researchers, policy makers, administrators, teachers, and parents with a benchmark from which to measure and evaluate variations from the education method Dr. Montessori bequeathed at the end of her life. In the ongoing search for alternative educational methods, the time-honored and burgeoning Montessori system is of considerable interest. Dr. Montessori conceptualized the system as a triangle for which the environment, the teacher, and the child formed the legs. Part I of this two-part article examines Dr. Montessori's view of what constitutes the environment, in terms of its material, temporal, and social features. An appendix to Part II summarizes the features.

> *I have studied the child. I have taken what the child has given me and expressed it, and this is what is called the Montessori Method.* (Montessori, 1961/2007, p. 2)

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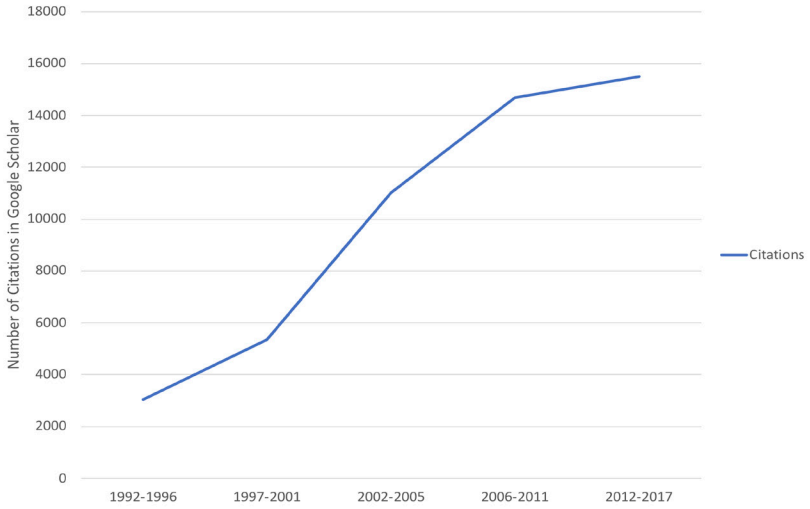

Figure 1. Citations in Google Scholar using "Montessori" as keyword, 1992–2017.

Montessori designates an educational method named after its founder, Maria Montessori, who, at the turn of the last century, was one of the first women physicians in Italy and a professor at the University of Rome (O'Donnell, 2007). Tens of thousands of Montessori schools exist worldwide, including the world's largest school (in Lucknow, India), and they have educated well-known people ranging from Anne Frank and Sean "Diddy" Combs to Julia Childs and Jeff Bezos. There is increasing research interest in Montessori education (see Figure 1), and most research indicates the Montessori system of education has good social-emotional and cognitive-academic outcomes (e.g., Ansari & Winsler, 2014; Besançon & Lubart, 2008; Bhatia, Davis, & Shamas-Brandt, 2015; Brown & Lewis, 2017; Culclasure, Fleming, Riga, & Sprogis, 2018; Debs & Brown, 2017; Dhiksha & Suresh, 2016; Dohrmann, Nishida, Gartner, Lipsky, & Grimm, 2007; İman, Danişman, Akin Demircan, & Yaya, 2017; Kayılı, 2018; Lillard & Else-Quest, 2006; Lillard, Heise, Tong, Hart, & Bray, 2017; Mallett & Schroeder, 2015; Marshall, 2017; Mix, Smith, Stockton, Cheng, & Barterian, 2017; Peng & Md-Yunus, 2014; Phillips-Silver & Daza, 2018; Rathunde & Csikszentmihalyi, 2005a, 2005b; Rodriguez, Irby, Brown, Lara-Alecio, & Galloway, 2005; Sebastian & Matheen, 2016; Yildirm Doguru, 2015). Yet not all studies show better outcomes (e.g., DeVries & Gonçu, 1988; Kirkham & Kidd, 2017; Krafft & Berk, 1998; Laski, Vasilyeva, & Shiffman, 2016; Lopata, Wallace, & Finn, 2005; Ruijs, 2017; Yen & Ispa, 2000), possibly because of differences in implementation (Lillard, 2012, 2019; Lillard & Heise, 2016).

Because the Montessori name is not protected by copyright, Montessori implementation can vary widely. Further, Dr. Montessori was continuously experimenting, and thus principles and practices evolved over her lifetime, "by following the child and his[1] psychology" (Montessori, 2012, p. 7). Here, we attempt to derive Dr. Montessori's ultimate core principles and practices from her lectures and books, thereby arriving at a description of *authentic* Montessori education, in the sense of "done in the traditional or original way" (*Oxford English Dictionary*, 2019). Our method was to study Dr. Montessori's books for descriptions of the system; we also reached out to the major repository of Montessori writings, the archives of the Association Montessori Internationale (AMI), which provided teacher-training documentation beyond what Dr. Montessori's books revealed. Her books are mostly compilations of her lectures; in addition to other talks, almost every year from 1914 to 1951 she gave at least one teacher-training course, resulting in an abun-

[1] Although an ardent feminist, Dr. Montessori used gendered language in keeping with the norm of her time.

dance of sources; we give precedence to the descriptions given in the later courses where they contradict early descriptions, suggesting evolutions in her thinking.

Other sources describe views of how Montessori education should be implemented; one example is "Essential Elements on Montessori Practice in the Public Sector," which stemmed from work in the 1990s by several Montessori organizations and was instantiated in a rubric created by the National Center for Montessori in the Public Sector (2015). The present article uses source material to explicate issues that Dr. Montessori viewed as important and does not discuss practical issues like school budgets and the teacher pipeline. We also make no claims as to how Montessori education should be implemented; rather, we provide a description of her view of what the system was, at her life's end, as a benchmark from which alterations can be described or measured.

Our approach is to present the material and theoretical characteristics of the Montessori *trinity*—the prepared environment, the teacher, and the child (Montessori, 2012)—and reference sources so interested readers know where to seek further information. The present article, Part I, presents the prepared environment as a set of features and practices adults enact or adopt. Part II examines the role of the teacher and teacher training and presents a Montessori view of the child. The section on the child begins with Montessori theory about children and their development and ends with what Dr. Montessori regularly observed: social, emotional and academic outcomes. Throughout both articles, research is described for elements of authentic Montessori about which especially pertinent or relevant research exists (for more, see Lillard, 2017, 2018).

It is worth reiterating that what we call "authentic Montessori education" is what Dr. Montessori described in her lectures and writings; we attach no value to "authentic" here. Dr. Montessori adjusted the approach in response to children's developmental needs based on her observations. Had she lived longer, her ideas would surely have evolved. However, as a variety of interests have changed the Montessori system in a variety of ways, and we cannot know how she would have changed her methodology, it seems useful to explicate authentic Montessori education in the sense of "done in the original way" (*Oxford English Dictionary*, 2019), meaning at the end of Dr. Montessori's life. Our rendition of authentic Montessori can be used as a benchmark from which researchers, policy makers, administrators, teachers, and parents can measure variations in implementation. Empirical science must determine which alterations are improvements and which are not.

In Montessori theory, the essential elements of education for human development comprise setting children free in a prepared environment with a specially trained teacher; these three features constitute a Montessori trinity (see Figure 2). As noted, the prepared environment, which has many components, is

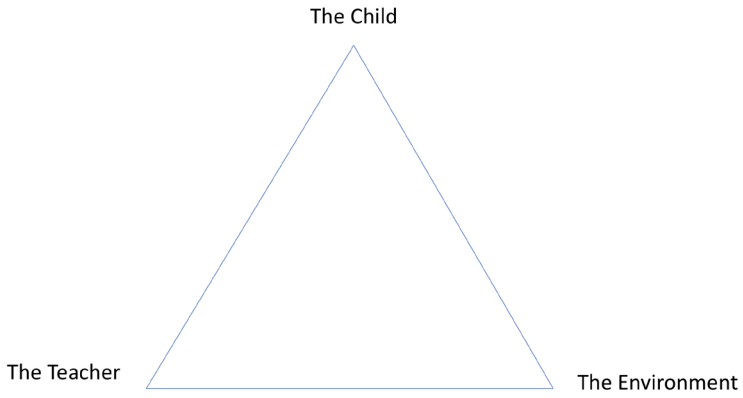

Figure 2. The Montessori trinity.

described in the remainder of this article. Throughout, we use the present tense because at least some Montessori environments currently implement each feature.

The Prepared Environment

> *One of the most urgent endeavors to be undertaken on behalf of the reconstruction of society is the reconstruction of education. It must be brought about by giving children the environment that is adapted to their nature*. (Montessori, 1949/1974, p. 100)

Montessori environments are carefully prepared by the teacher to provide opportunities for children's development while protecting children from obstacles to that development. Within the prepared environment, children are free to pursue their natural interests and respond to what Dr. Montessori considered an innate drive to work.

The Material Environment

The material environment consists of the physical space and its contents. In Montessori education, children's mental development and learning come not from a teacher but from directly interacting with Montessori materials: "Place everything necessary in the environment, and then leave the children free to function according to the laws of nature" (Montessori, 2012, p. 186). The classroom space and its contents are beautiful, inviting, and systematically organized. They include a predetermined set of materials and suit children of the ages they serve.

Suited to the child. "[A teacher must] conscientiously prepare an environment, placing educational materials about for some clear purpose and introducing the child with great care to the practical work of life" (Montessori, 1956, p. 76). Dr. Montessori's description of the furnishings of a classroom for 3- to 6-year-olds shows how everything is selected to suit the children's abilities, including

> *...light furniture that he can carry about; low dressers within reach of his arms; locks that he can easily manipulate; chests that run on castors; light doors that he can open and shut readily; clothes-pegs fixed on the walls at a height convenient for him; brushes his little hand can grasp; pieces of soap that can lie in the hollow of such a hand; basins so small that the child is strong enough to empty them; brooms with short, smooth, light handles; clothes he can easily put on and take off himself; these are surroundings which invite activity, and among which the child will gradually perfect his movements without fatigue, acquiring human grace and dexterity*. (Montessori, 1917/1965, p. 151)

The idea of having furnishings and implements adjusted to children's sizes was unusual in the era (Elkind, 1983; Montessori, 1961/2007, p. 3), although typical children's toys, across cultures, have long been miniatures of adults' tools, allowing children to begin to participate in adult work (Lancy, 2016). Dr. Montessori said, "Small children [in traditional cultures] have a tendency to work in their play, imitating the actions of the adults. They don't consider what they do to be play" (Montessori, 2012, p. 151). She reasoned that because children typically play at the practical work of adults, such activities might serve a developmental purpose better than does play with other kinds of toys that (she noted) only wealthy families could afford.

The Montessori exercises of Practical Life, "which have a useful aim" (Montessori, 1994b, p. 11), employ miniatures of adult tools to encourage intelligent activity of the hands, guided by the mind. Children can relate to the aim of these activities, which they see performed by adults. Indeed, research has shown that, given a choice between pretending to do activities like feed babies and wash dishes versus really doing them, even contemporary American children prefer to actually do things (Taggart, Heise, & Lillard, 2018). Specifically, about 75% of the time, given a choice between pretending to do an activity and actually doing it, children ages 4 to 6 chose the real activity; 3-year-olds chose the real activity 50% of the time. Further-

more, when children chose the pretend activity, they said they did so because they were afraid, incapable, or not allowed to do the real activity (for discussion, see Lillard & Taggart, in press).

In addition to letting children engage in Practical Life activities with appropriately sized objects, the Montessori environment includes objects that are light and fragile because children "will only perfect [their movements if they] can move among fragile objects" (Montessori, 2013a, p. 110), and mishaps are viewed as instructive. Montessori materials are logically and neatly arranged on low shelves, facilitating children's ability to find and use them.

The materials are also suited to children in another way: they are intended to respond to children's needs in their current stage of development. The environment for each age level (e.g., 0 to 3, 3 to 6) is said to correspond to core characteristics of children at that stage—discussed in a later section both here and in Part II—because "the task of education is to supply the needs of every stage from the beginning" (Montessori, 1961/2007, p. 53).

> *One of the problems of teaching is thus to discover the subjects best suited to children of different ages…, to their different interests. Our experience has demonstrated, for instance, that children are much more interested in learning the alphabet [and writing] at age four than at any other age*. (Montessori, 1972, p. 96)

Dr. Montessori experimented by watching how children of different ages reacted to different materials, and she designated the materials for ages of children for whom she inferred they were best suited. For example, the basic language materials are for children ages 2 to 6 because she found that time to be a sensitive period for language. A child of 7 does not respond to the Sandpaper Letters by realizing that "words are composed of sounds…. Only children at this early age, when they still have the sensitivity for language, do" (Montessori, 2012, pp. 232–233). Further, "the older children have a different form of mind, so the children in the elementary schools could not do what these [younger] children did; they could only learn writing slowly and very imperfectly" (Montessori, 2012, p. 17). The exercises of Practical Life, in which children engage hand and mind in purposeful activities like cleaning a table, arranging flowers to beautify the classroom, or cutting carrots to serve as snacks, are also only for the Primary classroom. Older children, although they do still care for their environments, no longer need a special arrangement of such activities: "The continuation of such exercises would be useless" (Montessori, 1948/1976, p. 17). Given Montessori education's systematic, hierarchical approach to building intelligence, a key issue for research is how to incorporate into a classroom those older children who lack a Montessori background and therefore did not have prescribed materials or activities during specific developmental periods.

Specific materials. Montessori education has a specific set of materials for each age level, grouped into curricular areas (e.g., Language, Sensorial, Cultural, Math, Geometry, Science). The materials are interdependent both within and across those areas, as well as within and across age levels. Practical Life materials, as well as some language materials, are selected and prepared by the teacher, whereas others are commercially available (but can also be homemade). The materials are "the means of development" (Montessori, 1917/1965, p. 86).

The material sets were carefully developed over the years to assist many aspects of children's development.

> *We must not abandon the child to a haphazard choice of objects.... He will try to understand this world, so we must give [a] beautiful, rich environment where a child can be free to choose whatever is necessary for his development*. (Montessori, 2012, p. 179)

Hence, there are objects to assist the development of concentration, organization, movement, and independence for children ages 0 to 6 (e.g., Practical Life and Sensorial materials), and at all levels, materials to assist the development of reading and math, of understanding the biological, physical, and social worlds,

Figure 3. The Timeline of Life. Photograph courtesy of Forest Bluff School.

and so on. The materials for the 6- to 12-year-olds appeal to reason and fuel their understanding of the universe through imagination, such as the Timeline of Life (see Figure 3), which motivates children to explore life on Earth, from the first cell on. In recreating parts of this chart, children face how recently current life forms evolved and explore how different forms mutated into other forms along the way.

Many Montessori materials, for example, the solid cylinders, sound boxes, and geometry cabinet, incorporate *control of error*, in that the materials themselves make clear to children when an error is made, that is, when a cylinder does not fit in its socket, or when, in a sound-cylinder-pairing task, the sounds emanating from the last two cylinders are not the same. Because of natural human tendencies toward precision and perfection (Kubovy, 1999), children are inclined to correct their own errors. Dr. Montessori believed that, just as young children's walking and speaking gradually improve, so do all their other endeavors. She was not concerned with immediate perfection. She saw what goes on in the classroom as developments that may require a great deal of time and repetition but that will indeed occur if children are given free opportunity to repeat exercises with materials that show them their own errors, just as surely as do balanced, coordinated walking and native-like language.

Authentic Montessori classrooms have specific materials that are hands-on, real, and purposeful: "When I gave the children this scientific material, they preferred it to toys because it responds to an urge in their nature; it enables them to develop" (Montessori, 2012, p. 16). Children select the materials they need for their development, and materials that do not appear to help children are removed from the set: "The material of our schools today is based on the selection that the children have voluntarily made themselves from the mass of things that was placed at their disposal" (Montessori, 1989, p. 64).

An authentic Montessori classroom includes a complete set of Montessori materials for the age level, no less and no more: "This selection [of materials by the children] brought to us the conception that there

must be just that amount and no more" (Montessori, 1989, p. 64). Perhaps an incomplete set limits a child's development in some areas, since the materials are designed to work together within and across areas of development. Therefore, if a material is missing from the set, aspects of development could be compromised. Dr. Montessori did not leave lists of the materials for each age level, but there are descriptions in her books. For example, *Psychoarithmetic* (Montessori, 1934/2016) details the math materials and *Psychogeometry* (Montessori, 1934/2011) the geometry ones. *The Advanced Montessori Method II* (Montessori, 1916/1965) describes the Elementary materials, and *Creative Development in the Child* (Montessori, 1994a, 1994b) details many of the Primary (and some Elementary) materials, as do *The Montessori Method* (Montessori, 1964) and *The Discovery of the Child* (Montessori, 1962/1967). The materials that are described in her books can be compared with lists provided by Montessori associations; regarding Primary classroom materials, one of us conducted a study of the views of American Montessori Society and AMI teacher trainers about what the essential materials are at the Primary level (Lillard, 2011).

Beyond not omitting any material, neither does an authentic Montessori classroom add material, such as worksheets or commercial toys, to the sets developed by Dr. Montessori. Research supports limiting the materials: children in Montessori classrooms holding only authentic materials performed better on many measures than did children in classrooms supplemented with a variety of other materials (Lillard, 2012; Lillard & Heise, 2016). Logically, adding materials could result in less use of materials developed by Dr. Montessori and her collaborators (e.g., her son Mario). In addition, given that the sequences of materials are carefully planned out, with one material building skills that are applied with subsequent materials (sometimes in other parts of the curriculum), it may be unclear where and how new ones fit. Finally, there is value in parsimony: too much choice is problematic (Schwartz, 2004), and "overabundance debilitates and retards progress" (Montessori, 1917/1965, p. 79). These reasons may explain why children performed less well on a wide range of outcome measures in classrooms that added non-Montessori materials (Lillard, 2012; Lillard & Heise, 2016).

As with any system, it is reasonable to think that improvements can be made to the Montessori materials, particularly if the improvements are suggested by people who deeply understand the materials and how they work together within and across classroom levels. Dr. Montessori and her collaborators adjusted the material sets as needed, and surely the sets would be somewhat different today had they continued. For example, materials for using computers and learning foreign languages would likely have been developed and introduced at appropriate points; there is a reference to an 8-year-old Montessori student choosing to teach himself Sanskrit (Montessori, 1949/1974), suggesting there was an interest in learning an additional language.

In addition to advising against adding different, non-Montessori materials, Dr. Montessori believed the classrooms should have just one set of each material.

> *The fundamental fact in preparation of the environment is to have only one set of each type of material. In many schools the teachers that came from our courses thought it would be better and give greater scope to have two whole sets in the school…. But it became evident that the discipline of the school is hereby slackened; and if one lessens the number of sets the discipline returns*. (Montessori, 1989, p. 64)

Among other reasons for not duplicating materials is that if a desired material is in use, a child may choose another, observe, or simply wait until the material has been put back on the shelf and therefore is available. As explained in Part II, Dr. Montessori found that this limitation resulted in courtesy and respect for others.

Beauty and organization. The teacher "must put everything in order in the environment. She must see that the material is in perfect order. She must see that everything is attractive so that the children will like the environment as soon as they enter it" (Montessori, 1989, p. 14). Thus, authentic Montessori classrooms

are aesthetically pleasing, because "beauty in the school invites activity and work" (Montessori, 1956, p. 96). Having simple, uncluttered classroom spaces is better for young children's learning (Fisher, Godwin, & Seltman, 2014), and, indeed, abundant research demonstrates the positive effects of order on children's development (Lillard, 2017, Chapter 10). Less research is available on children's aesthetics or the influence of beauty on learning and development, but we do know that children's concepts of human attractiveness align with those of adults (Langlois et al., 1987).

Access to nature and other spaces. Dr. Montessori lectured repeatedly on the benefits of children being in nature, exposed to animals and plants, fresh air and sunlight (Montessori, 1961/2007).

> *A child, who more than anyone else is a spontaneous observer of nature, certainly needs to have at his disposal material upon which he can work.... Children have an anxious concern for living beings, and the satisfaction of this instinct fills them with delight. It is therefore easy to interest them in taking care of plants and especially animals*. (Montessori, 1962/1967, pp. 70–71)

Recent research shows the strength of young children's interest in animals: even when attractive toys were also available in a free-play room, children spent much more time interacting with and talking about animals (LoBue, Bloom Pickard, Sherman, Axford, & DeLoache, 2013). Dr. Montessori noted that "the good we receive from nature is not alone a material benefit, it is also a great intellectual, and moreover, a spiritual benefit" (Montessori, 2013a, p. 179). She also said that "if a school has a garden attached to it, the care of the paths, the weeding of plants, or the gathering of ripe fruit, and so on" can be integral school activities (Montessori, 1962/1967, p. 82). Other research supports the health and cognitive benefits of nature (Berman, Jonides, & Kaplan, 2008; Kabisch, van den Bosch, & Lafortezza, 2017).

Dr. Montessori also suggested that, ideally, schools should allow children fairly open access to different classrooms: "The open door to the other rooms gives a freedom of circulation, between the different [levels], and this circulation is of the utmost importance for the development of culture" (Montessori, 1989, p. 65). The demarcations between classrooms were sometimes very low walls or rows of plants and aquariums (e.g., Montessori, 2013b).

The Temporal Environment

Montessori classrooms provide uninterrupted 3-hour work periods as is evident in the following quotation.

> *Our schools start with three to four hours of work and remain open longer and longer. Children begin to come in the afternoon. Then both the teacher and the children begin to get enthusiastic and remain a few hours longer in school*. (Montessori, 2012, p. 192)

Dr. Montessori appeared to be flexible regarding when children go home. If the school served as day care, she recommended a schedule of 9 a.m. to 5 p.m. or 8 a.m. to 6 p.m. (Montessori, 1964, p. 120): "If the daily schedule is very long, dinner will also form a part of [Practical Life activities]" (Montessori, 1962/1967, p. 82). Another example of a daily schedule Dr. Montessori endorsed was seen in her demonstration of the educational Method at the Panama–Pacific International Exposition held in San Francisco in 1915: the model classroom she set up operated from 9 a.m. to noon each day (Montessori, 1997).

The typical schedule of 3 uninterrupted hours in the morning and, for children 5 to 6 and older, 2 to 3 hours in the afternoon is apparently intended to give children time to become deeply absorbed in work and to develop self-awareness to guide further activity. One sees this in the Montessori work cycle (see Figure 4), which shows that from 9 a.m. to 10 a.m., children will likely choose easy work, followed by a period of false (i.e., apparent but not real) fatigue, when an inexperienced teacher might think children need recess or to gather in a circle. Then, from 10 a.m. to 11 a.m. or noon, what Dr. Montessori referred to as a period

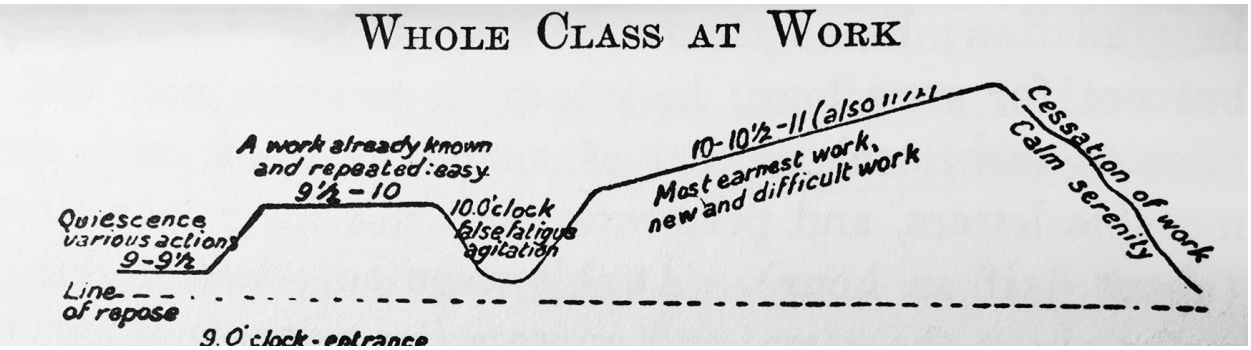

Figure 4. Whole class activity curve. Figure from Montessori (1917/1965), p. 98.

of "much longer duration" than the first and easy work, children engage in their "most earnest work, new and difficult work" (Montessori, 1917/1965, p. 103). Finally, over a period of 30 to 45 minutes (judging by the length of time depicted in the graph in Figure 4), children cease work; she noted that at this time they appeared serene. Ongoing research at the University of Virginia shows these cycles still hold today.

The full Montessori work cycle is thus about three hours long. Dr. Montessori cautioned, "If [children] are interrupted in their cycle, they lose all the characteristics connected with *an internal process regularly and completely carried out*" (Montessori, 1917/1965, p. 99, italics in original). As children develop, the first stage of the work cycle becomes more like the second one, so "all his intellectual occupations are of a higher order, as are also his moral attributes" (p. 106). The major impetus for all this development is the freedom to engage in and maintain focus on work of one's own choosing, hence not being interrupted during the work cycle (p. 108). Two of the rules Dr. Montessori instilled in teachers are to observe the children and to allow concentrating children to work uninterrupted (Montessori, 1994b).

The importance of the work cycle is noted throughout Dr. Montessori's books. Children "remain an hour, an hour and a quarter on the same exercise, at an age when [adults typically] want to limit his work to ten or fifteen minutes. [Children] work for whole days" (Montessori, 2013a, p. 22) at the same exercise. Having sufficient time to become absorbed in work is essential to Montessori education: "When a child is continuously interrupted while fulfilling cycles of activity, the child gradually [loses] the courage, the constancy, and the determination necessary for achievement [and] fails to acquire a habit of applying himself to purposeful ends" (Montessori, 1961/2007, pp. 53–54). Dr. Montessori also stated, "We must not interfere with a concentrating child, because something is happening inside that child" (Montessori, 2012). Cycles of deep concentration instigate a series of positive personality changes that Dr. Montessori called *normalization* (meaning "preparation to participate constructively in society," Shaefer Zener, 2006, p. 1), and any activity that disrupts the flow of concentration is problematic. Although research reexamining these issues in Montessori classrooms is in its early stages, Dr. Montessori's observations are consistent with work on flow and on task fragmentation in the workplace (Csikszentmihalyi, 1990; Mark, Gonzalez, & Harris, 2005; Mark, Gudith, & Klocke, 2008; Mark, Iqbal, Czerwinski, & Johns, 2014).

Authentic Montessori classrooms do not include a recess time in their schedules unless "the morning is very long" (Montessori, 1994b, p. 56). By "very long," she likely meant well over three hours, since in describing the activity curve she said false (i.e., apparent but not real) fatigue would lead misguided teachers to take children to recess. Conventional education gains greatly by including recess (Pellegrini & Bohn, 2005) to relieve children from sitting and listening for extended periods, as is increasingly asked even of very young children (Bassok, Latham, & Rorem, 2016). Although recess benefits may apply to children in Montessori environments, it seems unlikely that they do, because Montessori children can move around at will and can choose active work, like (when circumstances allow) taking a soccer ball outside with friends. If parents asked about a gymnasium, Dr. Montessori said, "this is because the parents have not understood

fully. If the children [in a Montessori classroom] are not getting enough exercise, [the teacher] must give them more work to do" (Montessori, 2012, p. 163). Exercise, she said, comes in the normal course of activities, except in schools that unnaturally require children to sit much of the time. Authentic Montessori programs also do not break for specials. Special subjects (e.g., art, music, drama, foreign language) are typically integrated into the classroom, although apparently the Elementary students may receive special instruction during one of the 10 weekly work periods; Dr. Montessori's granddaughter Renilde told one of us about a weekly music class in her Amsterdam Montessori Elementary school. However, such interruptions would be infrequent, as a "negative action is the interruption of work at fixed times in the daily program. They say to the child, 'Don't apply yourself for too long at any one thing'" (Montessori, 1967/1995, p. 241). Clearly, long, uninterrupted work periods are the norm for authentic Montessori.

Although we did not find explicit discussion of it, Dr. Montessori's books suggest that authentic Montessori classrooms enroll children consistently, with the same pattern each day (i.e., go to and leave school at the same hour), as would be "fixed by the Directress" (Montessori, 1964, p. 70) for several days in a row. For example, she said, "Repetitions awaken [a child's] interest. To create a cycle of relationship, it is advisable to take the child regularly [to the same environment]" (Montessori, 1961/2007, p. 22). A regular, daily school schedule establishes order, and "the tiny child's basic need for order takes priority over all other social claims that the world may make of him" (Montessori, 1967/1995, p. 135). Once a routine is established, children know what to expect daily, and research suggests this consistency leads to better outcomes as children thrive on routine and order (Lillard, 2017, Chapter 10). How varying the schedule, and adding specials or recess, affects Montessori student outcomes has not been systematically studied.

The Social Environment

The social environment of a Montessori classroom includes a relatively large (by American standards) number of children in particular age ranges. Once children begin to concentrate on work, Dr. Montessori claimed they easily adapt to and indeed thrive in the social environment (Montessori, 2012). This sequence of concentration–adaptation–thriving has not been empirically studied, although it is consistent with research on self-regulation (Rimm-Kaufman, Curby, Grimm, Nathanson, & Brock, 2009).

Three-year age groupings. Montessori classrooms are prepared for a 3-year age mix, in part because children can learn from and teach near peers. Dr. Montessori noted that "the older ones help the smaller ones and the small ones help each other. They show respect for and interest in each other" (Montessori, 2012, p. 233). Mixed age groups also reduce the competition that characterizes middle childhood: "Not only are these children free from envy, but anything done well arouses their enthusiastic praise" (Montessori, 1967/1995, p. 231). She further stated, "There is love and admiration on both sides [i.e., younger and older children]" (Montessori, 1967/1995, pp. 226–227). A third reason for the age mix is variety:

> *The charm of social life is in the number of different types that one meets.... To segregate by age is one of the cruelest and most inhuman things one can do…. It breaks the bonds of social life, deprives it of nourishment…. It is an artificial isolation and impedes the development of the social sense*. (Montessori, 1967/1995, p. 226)

While research strongly supports peer learning (Lillard, 2017, Chapter 7), research on multiage classrooms has mixed results (Ansari, Purtell, & Gershoff, 2016; Justice, Logan, Purtell, Bleses, & Hogden, 2017; Veenman, 1995, 1996; Wang & Su, 2009; Winsler et al., 2002). In many of these latter studies, classrooms were set up for whole-class instruction, not individualized instruction; in whole-class instruction settings, mixed age groupings can be problematic (Ansari et al., 2016). In addition, in conventional schools, where children are typically in teacher-led classrooms, they likely interact less and therefore the possible social benefits of interacting with people of different ages may not accrue.

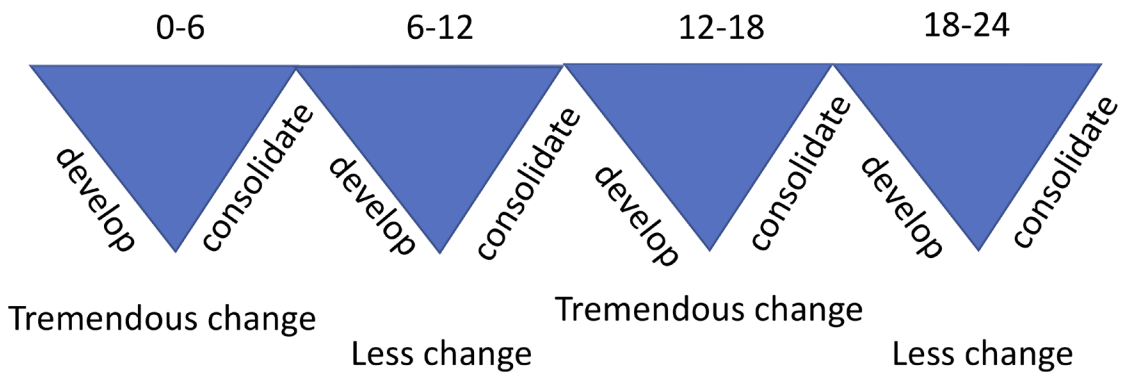

Figure 5. Montessori's stages (or planes) of development (adapted from Montessori, 2012, pp. 2–28).

Specific age spans. Authentic Montessori education mixes ages of specific ranges, in keeping with Montessori theory having four stages of development: 0 to 6 years, 6 to 12, 12 to 18, and 18 to 24 (see Figure 5). Across cultures, people commonly have marked 6 (or 7) years of age as a turning point in development (Rogoff, Sellers, Pirrotta, Fox, & White, 1975); this extends back to Plato (1970). Other early theorists like Comenius (who lived in the 1600s and to whose writing Dr. Montessori refers; see 1948/1976, p. 33) also observed childhood as consisting of four 6-year stages, ending at age 24 (Giardello, 2014).

Dr. Montessori described specific features of children in each stage of development (discussed more in the section on the child in Part II). The first and third stages are times of tremendous change, while the second and fourth are calmer. In addition, the first half of each stage entails more change, and the second half consolidates those changes. Dr. Montessori accordingly also divided each stage into two parts, making eight 3-year spans: 3 to 6, 6 to 9, and so on. During each distinct span, developmental characteristics are similar, and therefore a classroom can serve the needs of all children in that age range.

> *We cannot treat children the same way in the different developmental periods. They do not need the same care, the same environment, the same methods. If education is to be based on life, it must be adapted to all these differences*. (Montessori, 2012, p. 24)

For example, Dr. Montessori said, "If we study the psychology of children aged between three and six, we see that movement, and especially the movement of the hand, plays a most important part in mental development of children in this age" (Montessori, 2012, p. 16); research support for this is described elsewhere (Lillard, 2017, Chapter 2). Many of the materials aimed at 3- to 6-year-olds thus educate movement, especially the hand; such materials would no longer be appropriate for 7-year-olds. When there are fewer children, the entire second plane (i.e., ages 6 to 12) is sometimes housed in a single classroom because, according to Montessori theory, there is less change across that stage than in the ones preceding and following it. Thus, authentic Montessori education places children in specific, 3-year age groupings: 0 to 3, 3 to 6, 6 to 9, and so on.

Class size. Dr. Montessori clearly stated her views on class size, which is large by American standards today:

> *In its best condition the class should have between thirty and forty children, but there may be even more in number. That depends on the capacity of the teacher. When there are fewer than twenty-five the standards become lower, and in a class of eight children it is difficult to obtain good results. The really profitable results come when the number grows; twenty-five is a sufficient number, and forty is the best number that has been found*. (Montessori, 1989, pp. 64–65)

In one lecture, the range was 20 to 40 (Montessori, 2013b); regardless, she believed development was best "when the children are many and the teacher is only one" (Montessori, 1994a, p. 181).

Although Americans often assume smaller class sizes are better for children, research does not clearly support this assumption, even for conventional methods of education. Class sizes in the United States have decreased dramatically since the 1960s, with no increase in performance on tests like the Program for International Student Assessment (PISA)—although, admittedly, the variety of children served might have grown across that time as well, which may be why performance did not improve. Yet class sizes in Asia are typically large (i.e., 35 or more), and their performance on tests like the PISA is high. Most importantly, studies that have experimentally reduced class sizes have produced mixed results (Hoxby, 2000; Stecher, Bohrnstedt, Kirst, McRobbie, & Williams, 2001; Whitehurst & Chingos, 2011). Regardless, given Montessori education's radically different approach (elaborated below), it is unclear whether conventional classroom research even applies here; formal research on class sizes and outcomes in Montessori environments is needed.

Dr. Montessori's recommendation for class size was developed through observations and testing; she claimed that, in Montessori education, larger class sizes better support children's learning. One possible explanation is that because Montessori children learn in part via observation and imitation, in larger classes they can learn more because there are more examples to learn from. Larger classes also supply more potential peer tutors, and they also may be expected to better support social development, just as 3-year age spans may: "When classes are fairly big, differences of character show themselves more clearly, and wider experiences can be gained" (Montessori, 1967/1995, p. 225). Children in Montessori classrooms do have better social understanding (Lillard, 2012; Lillard & Eisen, 2017; Lillard & Else-Quest, 2006; Lillard et al., 2017). It is said that order is maintained in large Montessori classes by a delicate balance of freedom and discipline: "The child…is possessed of marvelous directives that come to him from within and from this social environment that is created for him…. Thirty or forty children work together in beautiful, attractive surrounding especially created for them" (Montessori, 1932/1992, p. 92). In starting a new class, some references (e.g., Montessori, 1961/2007) suggest that sometimes a new classroom may begin with 15 or so of the youngest age group and then expand each year as those children age. Once a classroom is established, Dr. Montessori suggested having eight to 13 children of each of the three ages in a classroom.

Adult visitors.

> *When we have visitors [they] come as guests and we expect them to respect our children as guests respect their hosts…. Guests do not ask, "what are you doing?," "why did you do that?," "what does this mean?" [Such questions] can destroy the child's sense of independence*. (Montessori, 1989, p. 8)

Visitors are often asked to sit quietly and observe in Montessori classrooms: "If we are careful not to interfere with children's activities and interests so long as they are not harmful, nature will see to the child's development" (Montessori, 1989, p. 8). Dr. Montessori also described schools with balconies from which teachers-in-training and visitors could observe without interfering with children's activities: "The only thing we recommended was that the people should be quiet" (Montessori, 1989, p. 67).

The role of parents. Dr. Montessori believed that parents play a critical role in their child's education. Parents are expected to send their children to school on time and well-groomed, "to cooperate with the Directress in the educational work" (Montessori, 1964, p. 61), and to "show the greatest respect and deference" (p. 71). They are also expected to meet regularly with the teacher to give an account of the child's home life and to get advice from the teacher. The Montessori environment was designed to be a natural extension of the home; the original classroom was an apartment in a housing project where the teacher lived as well. Dr. Montessori seemed to think it important that children have their own space; hence, she called the Primary classroom a *Children's House*, "where children are masters of the house" (Montessori,

2017, p. 2). Parents' direct involvement is kept minimal because "the child whom we have robbed of his own will [because parents substitute their own will for the child's] becomes difficult" (Montessori, 1956, p. 99). In larger families, children are "more normal because the parents have not time to occupy themselves with each one…with such intensity" (Montessori, 1994a, p. 182). Dr. Montessori clearly thought it important that parents understand the Montessori approach, and she lectured to and wrote articles for parents throughout her life (Montessori, 1956, 2017), but she thought parents should not be directly involved with children's activities in the classroom. In conventional settings, parent involvement is associated with better outcomes, but the typical interpretation of "parent involvement" is incorrect. The typical interpretation is that parents should be in the classroom with children. However, the strongest effects of parent involvement are seen when the term refers to parents having high expectations of children's academic achievement; the weakest (sometimes negative) effects are when it translates to parents helping with homework (Wilder, 2014). Parent involvement, as the term is used in research, is typically not about parents being inside the classroom. The parent-involvement research actually is consistent with Montessori education, in that parents can have high academic standards, and there is no homework for parents to be involved in. Montessori students do their work at school and independently of their parents. Research on how classroom processes and child outcomes may change when parents are present in Montessori classrooms is needed, but even in conventional settings, parents' presence in the classroom does not predict positive child outcomes.

Summary

In sum, the prepared Montessori environment includes certain material, temporal, and social characteristics that are expressed in Dr. Montessori's books. Although aspects might have changed had she lived longer, what we detailed here describes what she included in her last lectures and thus provides a benchmark description. The environment is beautiful and contains child-sized implements and the full set of Montessori materials and no more. The work period extends for about three hours, morning and afternoon, and may be longer if the school functions as a day care. There are no interruptions in the middle of this period, and specials are absent or rare. There are at least 25 children of particular age groupings that correspond to Dr. Montessori's stages, like ages 3 to 6, with just one teacher. This teacher is a key feature of the social environment and constitutes the second part of the Montessori trinity, described in Part II, which also includes an appendix summarizing the features just mentioned.

AUTHOR INFORMATION

†Corresponding Author
Angeline Lillard† is a professor of psychology at the University of Virginia and research partner at the Wildflower Foundation. She can be reached at P. O. Box 400400, Department of Psychology, University of Virginia, Charlottesville, VA 22904-4400, USA. Phone: 01-434-982-4750; Fax: 01-434-979-0411 or Lillard@virginia.edu.

Virginia McHugh is executive director emerita at Association Montessori International / USA and a partner at the Wildflower Foundation where she is a pedagogical coach for the Wildflower Schools in Cambridge, Massachusetts.

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Authentic Montessori: The Dottoressa's View at the End of Her Life Part II: The Teacher and the Child

Angeline S. Lillard[1] and Virginia McHugh[2]

[1]University of Virginia
[2]Association Montessori International (AMI) / USA

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Abstract: Part II of this two-part article continues the discussion of what Maria Montessori viewed to be the important components of her educational system. Because she developed the system over her lifetime, we prioritized later accounts when contradictory accounts were found. Whereas Part I focused on the environment, Part II examines the second and third components of the Montessori trinity: the teacher and the child. This article includes descriptions of Montessori teacher preparation, children's developmental stages, and the human tendencies on which Montessori education capitalizes. It ends with child outcomes as described by Dr. Montessori and as shown in recent research, and provides an appendix summarizing features of authentic Montessori described in Part I and Part II.

Over approximately 50 years, Maria Montessori gradually developed a system of education that she came to view as a *trinity* composed of the environment, the teacher, and the child. In Part I, we described how, she ultimately envisioned a proper Montessori classroom environment. Here in Part II, we describe the second and third parts of the Montessori trinity (or triangle): the teacher and the child. We conducted this work by carefully reading Dr. Montessori's books and compiling quotations describing the system; when contradictions appeared, later works were preferred. We also consulted the archives of the Association Montessori Internationale (AMI) for descriptions of the teacher preparation that Dr. Montessori used. We include these descriptions of teacher preparation and of what Mario Montessori (1956) described as the basic human tendencies, as well as of child outcomes described by Dr. Montessori and by recent research.

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As we emphasized in Part I, the term *authentic* is used to denote "done in the traditional or original way" (*Oxford English Dictionary*, 2019), not to imply that alterations to what she developed create systems that are necessarily inferior. We urge empirical study of the variations to determine whether they improve or detract from the system bequeathed by Dr. Montessori, and we supply the present description to provide a benchmark from which variations can be measured. We render descriptions in the present tense to reflect that some Montessori schools today use an authentic implementation.

The Teacher

> *Our care of the child should be governed, not by the desire to "make him learn things," but by the endeavor to always keep burning within him that light which is called intelligence*. (Montessori, 1917/1965, p. 240)

A Montessori teacher has three essential tasks: to prepare the environment, to set the children free in it, and, once children begin to concentrate, to observe without interfering in children's self-construction, (i.e., the process by which children actively and gradually create their own knowledge and understanding and, eventually, their adult self). Dr. Montessori went to great lengths to highlight the importance of a particular style of observation.

> *The first step to take in order to become a Montessori teacher is to shed omnipotence and to become a joyous observer. If the teacher can really enter into the joy of seeing things being born and growing under his eyes, and can clothe himself in the garment of humility, many delights are reserved for him that are denied in those who assume infallibility and authority in front of a class*. (Montessori, 1948/1967, p. 122)

The teacher, unbeknownst to the children, thus evaluates the class on an ongoing basis and introduces new work to children at appropriate times. Developing the necessary attitude and the sensitivity to correctly evaluate what is needed requires that teachers have special training, which is briefly described at the end of this section.

The Teacher's Role

Preparing the environment. The teacher's first major task is to prepare the environment in which he or she will set each child free. This environment was mostly described in Part I; one feature of the environment not described in Part I is the teacher. Dr. Montessori was specific about how a teacher should prepare him- or herself: "The teacher expects the children to be orderly and so she must be orderly…. The teacher… must be well cared for and well dressed. She must be clean and tidy and form part of the attractiveness of the environment" (Montessori, 1989, p. 14). The authentic Montessori teacher is "warm, caring, and understanding" (Montessori, 2012, p. 114), shows "respect [and is] humble" (Montessori, 2012, p. 34). However, in relation to the children, the teacher is also "superior, and not just a friend…. The teacher and the children are not equals [and] the children must admire the teacher for her importance. If they have no authority, they have no directive" (Montessori, 2012, p. 230).

In Montessori theory, the teacher's attitude toward the children is founded on a desire to serve humanity and a willingness to step out of the limelight to allow the children to show him or her where they are in their development through their work. The greatest sign of success for a Montessori teacher is to be able to say, "The children are now working as if I did not exist…. I have helped this life to fulfill the tasks set for it by creation"(Montessori, 1967/1995, p. 283). Many people have observed that children in Montessori classrooms do not change their behavior when the teacher is absent; rather they continue working and conversing just as they do when the teacher is there (Lillard, 2017, p. 106; Montessori, 1939, pp. 165–166).

Setting the children free. Once the environment is prepared and the children are present, there is a preliminary period before the class becomes a true Montessori class. Dr. Montessori called this "the collective stage of the class [when] the teacher can also sing songs, tell stories, and give the children some toys" (Montessori, 1994a, p. 183). The Primary teacher in this stage begins to show children how to use Practical Life materials, conveying "interest, seriousness, and attention" (Montessori, 2012, p. 75). However, if the class becomes chaotic, the teacher engages the children in a group activity like clapping or moving chairs together (Montessori, 2012, p. 230). Then and always, "the teacher must first study how to help the children to concentrate" (Montessori, 2012, p. 224); early on, a teacher needs to "use any device to win the children's attention" (Montessori, 1946/1963, p. 87). Teachers must be patient because "children do not become little angels overnight" (Montessori, 2012, p. 216). In *The Discovery of the Child,* Dr. Montessori discussed some of the difficulties encountered when establishing a classroom and how a teacher should respond (Montessori, 1962/1967).

But finally, one by one, children begin to concentrate. Concentration often begins with Practical Life activities (Montessori, 2012, p. 74), but it could also occur with moving furniture or watching a bug: "The [Montessori] material has not yet suitable conditions for its presentation" (Montessori, 1946/1963, p. 88). Dr. Montessori noticed, and believed teachers too should notice, that with the onset of deep concentration, children's personalities begin to change.

> *After the children concentrate, it is really possible to give them freedom. The teacher must…give them many opportunities for activity. She must give them material—an abundance of material—because once these children concentrate, they become very active and very hungry for work…. The teacher must see that there are many possibilities for work in the environment*. (Montessori, 2012, p. 232)

Noninterference. Once concentration begins, Dr. Montessori was very clear: teachers must not interrupt.

> *The teacher must recognize the first moment of concentration and must not disturb it. The whole future comes from this moment and so the teacher must be ready for non-interference when it occurs. This is very difficult because the teacher has to interfere at every moment before the child is normalized*. (Montessori, 1989, p. 15)

Dr. Montessori used the word *normalized* to mean "a return to normal conditions" (Montessori, 1936, p. 169), when the child is not perturbed in his or her development.

> *As soon as concentration appears, the teacher should pay no attention, as if that child did not exist. At the very least, he must be quite unaware of the teacher's attention. Even if two children want the same material, they should be left to settle the problem for themselves unless they call for the teacher's aid. Her only duty is to present new material as the child exhausts the possibilities of the old*. (Montessori, 1946/1963, p. 88)

Dr. Montessori observed that teachers typically try to do too much. As with parents, it is difficult for them not to interfere—they praise children or correct mistakes when, in the Montessori view, they should instead oversee the environment in a way that protects the child's absorption in work. She gave teachers some hints for how to hold themselves back from interfering with children's self-development (e.g., wait 2 minutes or count a string of beads; Montessori, 1994b, p. 34). She also believed that classrooms with a large number of children and a small number of adults reduces adult interference.

Dr. Montessori's books usually describe classrooms with only a single teacher for the 30 to 40 (or even more) children (see Part I for citations on this point). She once mentioned a school with classrooms of 30 children and one teacher and "sometimes with an assistant" (Montessori, 1989, p. 67), but assistants in the classroom appear to have been rare. Current teacher–child ratio regulations may require more adults, but Dr. Montessori was concerned that the presence of more adults in the classroom leads to more interference with

children's development. This raises two key principles that recur in Dr. Montessori's writings: (a) every bit of unnecessary assistance given to a child interferes with the child's self-development, and (b) the role of the teacher is limited: "In our schools the environment itself teaches the child. The teacher only puts the child in direct contact with the environment, showing him how to use various things" (Montessori, 1956, p. 138).

Presentations. Besides tending the children's environment, and respectfully giving children freedom to self-construct, integral to the Montessori teacher's role are the timing, content, and spirit of lessons, termed *presentations*, since typically a material and its use is presented. The teacher determines what a child is ready for next and introduces that activity at the right moment and in a captivating way, "as something of great importance" (Montessori, 1994a, p. 194). Dr. Montessori believed that "knowledge must be taken in through the imagination and not through memorization" (Montessori, 2012, p. 192). Correctly timing presentations requires continuous, close, and sensitive observation, as well as good record keeping and lesson planning: "You may have a beautiful orderly class, but if you abandon it, it will be lost after a time" (Montessori, 2012, p. 237). Thus, Dr. Montessori was specific about the timing and spirit with which teachers give presentations. For teachers to regularly and correctly present each material in a sequence in a timely manner, they must keep detailed and organized records on each child.

Evaluation. Dr. Montessori did not support the idea of tests as commonly conceived (e.g., typical multiple-choice tests).

> *How can the mind of a growing individual continue to be interested if all our teaching is around one particular subject of limited scope, and is confined to the transmission of such small details of knowledge as he/she is able to memorize?* (Montessori, 1948/1967, p. 6).

Yet, of course, a teacher must evaluate student progress. Dr. Montessori's books suggest that teachers evaluate students in at least two ways. First, the teacher observes children intensely, noticing what they are doing and appear to understand. In the course of this observation, a teacher may notice a child using a material incorrectly; for example, a child may neglect to trace the outside of a geometric form. In theory, this tracing action embodies the concept; for example, the child feels with his or her hand and arm what a pentagon is. Therefore, by neglecting to trace the shape, the child fails to embody the concept. In such a case, no immediate correction is given. What matters is that a child is engaged with the material; correctness will come. "If we correct him, we humiliate and discourage…. So the only way to correct the child is to prepare this material and give him the technique" (Montessori, 1994a, p. 191). The teacher simply notices the child's error and gives the presentation again later. Dr. Montessori expressed faith that through repetition, children will eventually learn, and that problems will typically be resolved without teacher correction. Her belief is consistent with the idea that humans under normal conditions have a tendency toward virtuosity; they get pleasure out of striving toward perfection (Kubovy, 1999). Since most Montessori materials have the feature of *control of error*, meaning the materials reveal one's mistakes, then if children do naturally strive for perfection, repetition will naturally lead to children using materials in the right way. The second way that teachers evaluate student progress is to check, via observation or discussion, children's knowledge prior to or while presenting a new lesson. This process is formalized in the three-period lesson (Montessori, 1994a, p. 204), in which teachers first give new information and then, in the course of conversation or through students' work, see that children can recognize the information, and, finally, in the third period, that children can even recall the information without prompting.

Supporting this last point, psychologists have discovered a *testing effect*: when people have already learned information (e.g., which new foreign word corresponds to a native word), future retrieval of that knowledge is improved not so much by further study as by repeated testing of the material (Karpicke & Roediger, 2008). One might ask if the testing effect means Montessori education would do well to test children in more-typical ways, but testing is built into the system Dr. Montessori designed. As just noted, the second two periods of the three-period lesson are recognition and recall tests. In addition, when children learn material, they try to recall what they can (e.g., the names of African countries while doing a Puzzle

Map), and then they use a different material (e.g., a Control Map) to determine for themselves whether they were correct. A third type of recall test that children repeatedly engage in after age 6 involves presenting material to others, as when giving oral reports. Montessori education therefore may already involve repeated, but perhaps relatively unstressful, testing of the sort that has been shown to improve learning.

In sum, an authentic program has a single Montessori teacher whose task is to guide, facilitate, and observe the community of children. In many places today, more adults are required in the classroom for state accreditation, a change to Dr. Montessori's approach that is ripe for empirical study.

Teacher Preparation

Dr. Montessori believed teaching with her system required self-study and sometimes even fundamental change: "A Montessori teacher must be created anew, having rid herself of pedagogical prejudices" (Montessori, 1946/1963, p. 86). She spoke repeatedly of teacher preparation involving spiritual and moral transformation, cultivating humility and patience, sympathy and charity.

> *This method [of education] not only produces a reformed school but above all a reformed teacher, whose preparation must be much deeper than the preparation traditionally offered. [The] mission is to be a scientist and a teacher: a teacher in the sense of an observer who respects life, drinking in the manifestations and satiating [the] spirit. Hence it greatly raises the personality of the teacher*. (Montessori, 2013, p. 276)

She said that the transformation to becoming a real teacher requires time and deep personal work.

> *It is not so easy to educate anyone to be a good teacher. It is not enough to study at a university. Perfection is a part of life; in order to achieve it, we must make a long study. Conversion cannot come to everybody. We must patiently try to understand and act on our understanding. Our conversion must be in the heart.* (Montessori, 2012, p. 26)

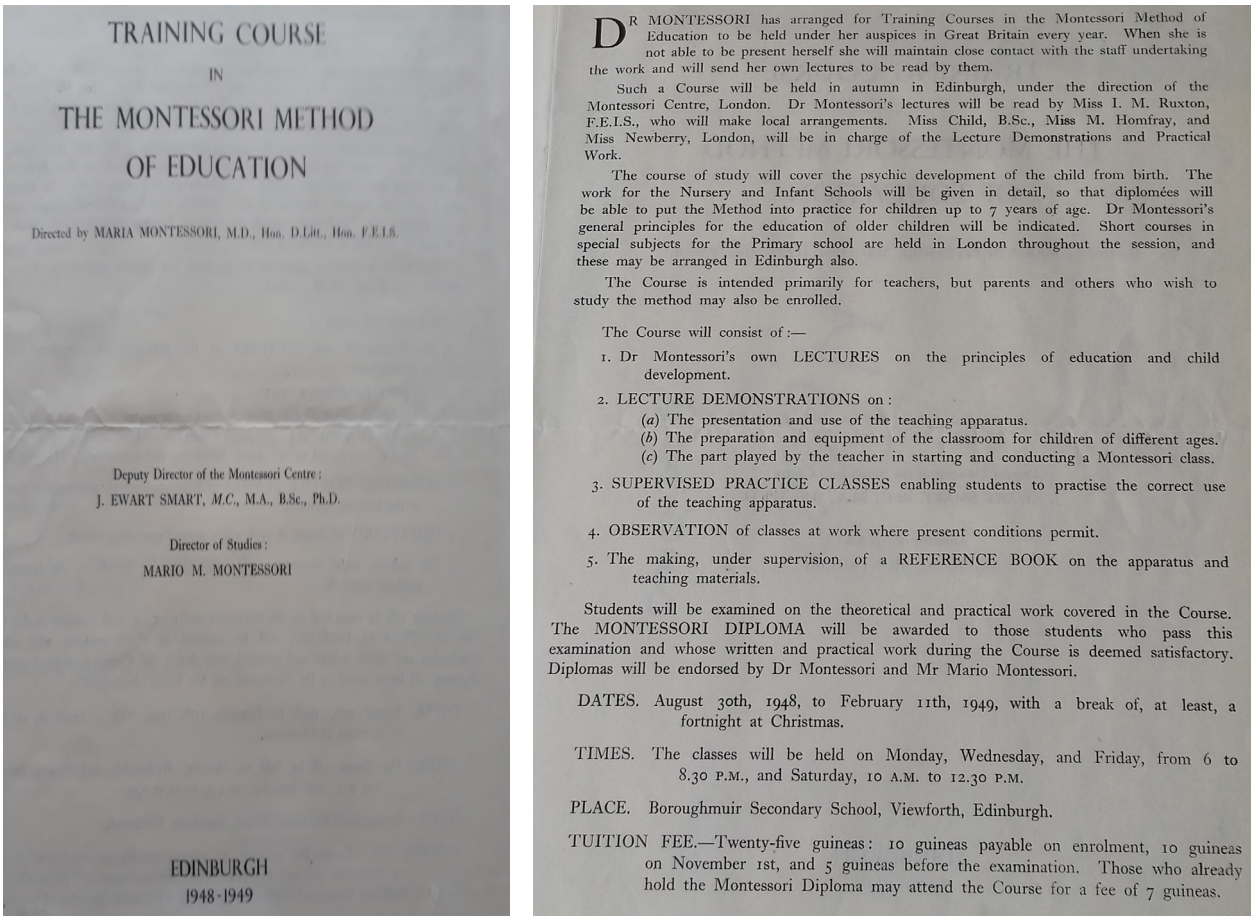
The teacher preparation required for both undergoing this personality change and learning the Montessori system, including its extensive set of materials, is quite involved.

The teacher preparation that Dr. Montessori ultimately delivered lasted about five months and included about 180 hours of lectures on the principles of education and child development, as well as lectures that included demonstrations of how to present and use the materials, how to prepare the classroom, and the teacher's role in starting and conducting the class (Montessori, 1948; see Figure 1). At its most developed (Montessori, 1994b, 2012), teacher preparation included more than 50 hours of lectures to cover all the materials, including their presentation, direct and indirect aims, target age range, and how the materials are self-correcting. There were also 50 hours of classes in which teachers-in-training practiced presenting the materials until they could do so perfectly and in which they also experimented with alternative ways of using the materials.

> *To keep a child within certain limits, [the teacher] must offer the material to [children], following a certain technique. So the teacher must have a direct communication with this material, and use it with the necessary exactitude. She must practice repeatedly in order to experiment and discover within herself the difference between using the material incorrectly and using it with exactness*. (Montessori, 1994b, p. 107)

Dr. Montessori urged teachers to experience the materials as a child would. In her own house, she often left materials out on the coffee table for continual exploration (Standing, 1957).

To enable teachers to learn to see children objectively and detect their needs, training also required at least 50 hours of observation: "The eyes of the teacher must be trained. A sensitivity must be developed in the teacher to recognize this ephemeral phenomenon of concentration when it occurs" (Montessori, 2012, p. 226). Eventually in this process, a developing teacher becomes "aflame with interest, 'seeing' the spiritual



TRAINING COURSE

IN

THE MONTESSORI METHOD

OF EDUCATION

Directed by MARIA MONTESSORI, M.D., Hon. D.Litt., Hon. F.E.I.S.

Deputy Director of the Montessori Centre:
J. EWART SMART, *M.C.*, M.A., B.Sc., Ph.D.

Director of Studies:
MARIO M. MONTESSORI

EDINBURGH
1948-1949

DR MONTESSORI has arranged for Training Courses in the Montessori Method of Education to be held under her auspices in Great Britain every year. When she is not able to be present herself she will maintain close contact with the staff undertaking the work and will send her own lectures to be read by them.

Such a Course will be held in autumn in Edinburgh, under the direction of the Montessori Centre, London. Dr Montessori's lectures will be read by Miss I. M. Ruxton, F.E.I.S., who will make local arrangements. Miss Child, B.Sc., Miss M. Homfray, and Miss Newberry, London, will be in charge of the Lecture Demonstrations and Practical Work.

The course of study will cover the psychic development of the child from birth. The work for the Nursery and Infant Schools will be given in detail, so that diplomées will be able to put the Method into practice for children up to 7 years of age. Dr Montessori's general principles for the education of older children will be indicated. Short courses in special subjects for the Primary school are held in London throughout the session, and these may be arranged in Edinburgh also.

The Course is intended primarily for teachers, but parents and others who wish to study the method may also be enrolled.

The Course will consist of:—

1. Dr Montessori's own LECTURES on the principles of education and child development.
2. LECTURE DEMONSTRATIONS on:
   (*a*) The presentation and use of the teaching apparatus.
   (*b*) The preparation and equipment of the classroom for children of different ages.
   (*c*) The part played by the teacher in starting and conducting a Montessori class.
3. SUPERVISED PRACTICE CLASSES enabling students to practise the correct use of the teaching apparatus.
4. OBSERVATION of classes at work where present conditions permit.
5. The making, under supervision, of a REFERENCE BOOK on the apparatus and teaching materials.

Students will be examined on the theoretical and practical work covered in the Course. The MONTESSORI DIPLOMA will be awarded to those students who pass this examination and whose written and practical work during the Course is deemed satisfactory. Diplomas will be endorsed by Dr Montessori and Mr Mario Montessori.

DATES. August 30th, 1948, to February 11th, 1949, with a break of, at least, a fortnight at Christmas.

TIMES. The classes will be held on Monday, Wednesday, and Friday, from 6 to 8.30 P.M., and Saturday, 10 A.M. to 12.30 P.M.

PLACE. Boroughmuir Secondary School, Viewforth, Edinburgh.

TUITION FEE.—Twenty-five guineas: 10 guineas payable on enrolment, 10 guineas on November 1st, and 5 guineas before the examination. Those who already hold the Montessori Diploma may attend the Course for a fee of 7 guineas.

Figure 1. Description of a Montessori teacher preparation course (Montessori, 1948).

phenomena of the child, and experiences a serene joy and an insatiable eagerness in observing them…. At this point she will begin to become a 'teacher'" (Montessori, 1917/1965, p. 141). Along with the teacher-trainer monitoring and observing these developments in budding teachers, written and oral exams were administered at the end of the courses. Oversight of the examinations for AMI courses was (and remains today) centralized at AMI headquarters in Amsterdam.

To help teachers-in-training to learn the material as well as to provide a manual and guide for their later teaching, they were also required to create reference books, often referred to as *albums*, rendering their lecture notes complete with illustrations, which the teacher trainers read for accuracy and understanding. Supporting this practice, research suggests that writing one's own notes—and by hand, not with a computer—results in a deeper conceptual understanding of the material (Mueller & Oppenheimer, 2014).

We have provided details about the teacher preparation provided by AMI because it is the organization Dr. Montessori founded to carry on her work and thus fits our definition of authentic or the state of the art at her death. It may be of interest to readers that her son Mario extended the duration of AMI courses to at least one academic year (personal communication, J. Verheul, January 31, 2018, based on a letter from Mario M. Montessori to Prof. Sulea Firu, December 1, 1976). He appears to have taken this action because he and Dr. Montessori found that even the intensive teacher-preparation courses were not necessarily enough to prepare a teacher.

> *Sometimes, the teacher in our schools succeeds very quickly and very easily. Very often she succeeds in practice only after long experience. This depends upon the nature of her spirit.*

> *She may need a long period of training in order to change her spirit and give it another form. This comes with practice, contact with children, and experience*. (Montessori, 1994a, pp. 104–105).

Demonstrating that the course itself had not always fully prepared them, teachers wrote letters to Dr. Montessori describing their classes and soliciting advice after training was over.

Dr. Montessori did not consider completion of her course sufficient for becoming a trainer of new teachers; the course pamphlets and diplomas from as early as 1914 explicitly stated that the diploma enables pupils to direct Children's Houses but not to train other teachers. It is unclear what she required for other trainers, as there were very few in her lifetime. Her son Mario was a trainer for the 1939 India course (he had received his diploma in 1925), and Claude Claremont ran a 2-year residential course in London. Undoubtedly, there were others whom she believed understood the system well enough to train teachers, and others helped with the practicums; for example, the Edinburgh brochure excerpted in Figure 1 named three people who did lecture demonstrations and practical work for the course.

Summary

Dr. Montessori believed that the teacher's role is to prepare the environment and then set the children free there, connecting children to the materials at appropriate times to engender states of deep concentration and wonder. Careful and astute observation is required to determine when interference is helpful, when children have mastered a material, and what new materials to present and when. Teachers typically want to do too much; learning to sit back and not interfere is crucial. In addition to listening to lectures, engaging in practicums, doing observations, creating albums, and passing examinations, Montessori teachers were expected to undergo a deep, spiritual transformation.

The Child

Dr. Montessori had a particular view of children and saw particular outcomes resulting from the system she developed.

> *The child is…capable of developing and giving us a tangible proof of the possibility of a better humanity [and] has shown us the true process of construction of the whole human being. We have seen children totally change as they acquire a love for things and as their sense of order, discipline and self control develops within them…. The child is both a hope and promise for mankind.* (Montessori, 1932/1992, p. 35)

In this section, we discuss Dr. Montessori's view of children, along with her stage theory and the human tendencies around which the Montessori system is constructed. Finally, we elucidate her view of the outcomes of this system of education.

How Development Occurs

Underpinning Montessori education is a view of children that was revolutionary in the early 1900s but is well accepted today. Fundamentally, this view is that, although children can be taught pieces of information (Harris, 2012), development occurs through self-construction. Conventional education is more oriented to the former view (see Resnick & Hall, 1998), whereas Montessori education is oriented to the latter.

Dr. Montessori derived her views about self-construction from watching very young children. Human babies essentially teach themselves how to get milk from the breast, grasp objects, crawl, and walk. She often used the example of language, noting that at around four months of age, children become intensely fo-

cused on adults' mouths when the adults speak (e.g., Montessori, 1961/2007, p. 27), a conclusion confirmed by current scientific methods (Lewkowicz & Hansen-Tift, 2012). Long before Noam Chomsky (1993) became famous for the same idea, Dr. Montessori repeatedly pointed out that learning language is an innate ability and that children everywhere learn language on a similar schedule, despite the varying levels of complexity of the different languages they learn. Further, they are not taught to do this; rather, they absorb language from the environment. Language is a supreme example of how children self-construct when their environment provides them appropriate raw material and the freedom to develop themselves. Assisting their self-construction is the fact that they gravitate to their "zone of proximal development" (Vygotsky, 1978), in other words, what is just beyond their current level of development. For example, infants seek stimuli that are challenging (but not too challenging) for them to perceive, a phenomenon recently dubbed *the Goldilocks effect* (Kidd, Piantadosi, & Aslin, 2012, 2014).

Dr. Montessori believed a children's self-construction has a blueprint and is guided by mental powers that are unique to each developmental period, stages she termed *planes of development*, which are depicted in Figure 5 in Part 1, where they were discussed with reference to the environment and materials offered at each stage. Here we discuss the stages with reference to children.

Planes of Development

Dr. Montessori attributed to William James an insight that child development can be likened to the metamorphic stages of a butterfly (Montessori, 2017), in that development is not simply a matter of growing and accruing, but that at each stage a child has a fundamentally different mind. Her system of education was adjusted at each stage to meet children's changing needs. Like many other theorists (see Part I), she saw three main stages of childhood, and a fourth stage as one enters adulthood (not discussed here).

The first plane: The absorbent mind. For a newborn child, the world is in most ways completely novel—all the sights and smells and tactile elements are new; only the sounds that penetrated the uterine wall and some tastes are familiar. Children are also relatively helpless, beholden to their caretakers for food and shelter. However, newborns also have the power to build their future selves and eventually become persons of their time, place, and culture. Certain qualities assist this early development and characterize the period from birth to 6 years.

Dr. Montessori observed that during this first stage, children effortlessly absorb many aspects of the environment, including language and culture, and that they do so without fatigue. This absorption is indiscriminate, incorporating both good and bad. However, these qualities disappear by the age of 6, when conscious learning takes hold.

> *This absorbent mind does not construct with a voluntary effort but according to the lead of "inner sensitivities" which we call "sensitive periods" as the sensitivity lasts only…until the acquisition to be made according to natural development has been achieved*. (Montessori, 1949/1974, p. 85)

During sensitive periods, particular elements in the environment evoke very strong interest, facilitating learning. For example, Dr. Montessori described the age of 2 as a sensitive period for order; she noted that children who see things out of place become upset and try to restore order (e.g., Montessori, 1967/1995, pp. 134–135). Montessori education capitalizes on these theorized sensitivities, for example, by showing young children precise ways to use and store materials.

> *Little children have, during their sensitive periods, powers that disappear later on in life. Once a sensitive period is over, the mind has acquired the special faculty, which this sensitivity helped construct; the individual must now learn in a different way. Whereas the small*

> *child learns easily, older children learn because they wish to learn, but they do so with effort.* (Montessori, 2012, p. 18)

The second plane: The reasoning mind. "The passage [from the first] to the second level of education is the passage from the sensorial, material level to the abstract" (Montessori, 1948/1976, p. 11). During this period, Dr. Montessori claimed children have an insatiable appetite for knowledge and are eager to explore with a reasoning mind, which begins to assert itself strongly: "From seven to twelve years, the child needs to enlarge his field of action" (Montessori, 1948/1976, p. 9). Children start wanting to understand the reasons behind things. No longer satisfied in a small community of the family and the preschool classroom, a child in the second plane wants to be part of a herd and engage predominantly in small-group work. The child "will try to get out, to run away, as he wants to augment the number of people who are in real relation with him" (Montessori, 1994a, p. 126). The Montessori system accommodates this in part with the Going Out program of the Elementary-level class, in which children venture out of the classroom to conduct research for reports on topics they find interesting and then often present the report to the class.

Dr. Montessori's overarching educational plan for the second plane is called *cosmic education*. Cosmic education allows for the use of the imagination and abstraction, with stories and experiments as the new tools for learning. Cosmic education is suited to this second plane because children of this age seek to understand their place in the universe and begin to think about justice as "the great problem of Good and Evil now confronts [them]" (Montessori, 1948/1976, p. 12).

The third plane. Dr. Montessori noted that 12 to 18 years of age is a period of great transformation, both physical and mental. As in the first plane, she saw the first half of the stage as a time of extreme change and the second half as a period of consolidation (Montessori, 1967/1995, Chapter 3). During the third plane, immense physical growth takes place. Psychologically, the adolescent experiences "doubts and hesitations, violent emotions, discouragement and an unexpected decrease of intellectual capacity" (Montessori, 1948/1976, p. 101). Children are preparing for their adult roles in society and need to practice adulthood in a physically and emotionally safe place. Country life—being close to nature and independent of the family—is suitable for this stage of development (Montessori, 1948/1976). Real work is essential, entailing gross motor activity and practical skills. For example, children in the third plane might apprentice with a craftsperson or run a small business on a farm. Being in a society of their peers is crucial. Academic studies continue but with a connection to self-generated, useful occupations. Creative expression, scientific skills, and an understanding of the world that the adolescents will soon enter as adults are important components of Montessori programs aimed at this age level.

In sum, Dr. Montessori saw in each developmental period distinct psychological characteristics that the Montessori education system responds to. She also saw certain tendencies that were characteristic of all people at all stages of development; these are discussed next.

The Human Tendencies

A central tenet of Montessori theory is that, throughout life, all humans exhibit certain tendencies on which education can capitalize. Dr. Montessori spoke of these tendencies repeatedly (indeed, they appear in her quotations throughout this article), and they were formalized by her grandson Mario:

> *The child possesses [certain human tendencies,] potentiality at birth, and makes use of them to build an individual suited to his time…. It is logical that if one can discover both tendencies and sensitive periods, and one is able to [support] them, [one] will have found a secure and permanent foundation on which to base education if education is viewed as a help to fulfill the optimum potential of the child.* (M. M. Montessori, 1956, p. 23)

In Montessori theory, humans, like many animals, tend to explore their environments and to find their place (i.e., orient) in the environment, both physically and socially. Montessori education gives children organized environments in which to respond to these tendencies and to explore and orient themselves. Children also have natural tendencies to be active and to engage in work. This work often takes the form of manipulating objects with the hands, another human tendency. Humans also respond well to order and seek to put things in order, to classify and categorize. In all of this, children are driven toward precision and self-perfection, both of which are accomplished through repetition. Finally, humans also have tendencies to abstract rules from sets of phenomena and to communicate what they think and feel to others.

These tendencies account for human survival, leading humans to seek from the environment what they need for their development, whether it be food or shelter, or practice walking or writing. Montessori environments respond to these tendencies, enabling children to discover the world for themselves, much as all humans have done since the dawn of our species. Authentic Montessori classrooms are set up to respond to these tendencies across all stages of development. What we believe is unique in Dr. Montessori's theory is not noting these tendencies, which are repeatedly observed in science; what is unique is that she developed an educational system to respond to these tendencies. When children spend time in this educational system, Dr. Montessori observed, certain characteristics become manifest. These observed child outcomes are discussed next.

Child Outcomes

Dr. Montessori frequently described what children become after developing in the environments she created with teachers who implemented the system properly. She described students in Montessori classrooms as "equipped in their whole being for the adventure of life, accustomed to the free exercise of will and judgment, illuminated by imagination and enthusiasm" (Montessori, 1948/1967, p. 1). To be "equipped in their whole being for the adventure of life" is difficult to address empirically, but we do know that Montessori children have free choice all day long and that the materials they use require them to repeatedly make judgments. Clearly, then, Montessori students are accustomed to the free exercise of will and judgment. Some studies indicate that Montessori children are especially creative (Besançon & Lubart, 2008; Besançon, Lubart, & Barbot, 2013; Lillard & Else-Quest, 2006), although not in drawing when compared to children in Steiner schools, which emphasize art (Cox & Rowlands, 2000; Kirkham & Kidd, 2017; Rose, Jolley, & Charman, 2012).

Dr. Montessori also described Montessori children as active and their activity as leading to joy and equanimity: "Left to themselves, the children work ceaselessly…. The children find joy, satisfaction, and exhilaration in work…. Work then becomes the *sine qua non* of growth, development, efficiency and happiness" (Montessori, 1961/2007, p. 87). A Montessori classroom, she said, hums like a hive of busy bees (Montessori, 1994a, p. 83) as the children go about their work, independently, calmly, and happily (Montessori, 2012, p. 156). Research on the social characteristics of Montessori children, although not always aligning with these descriptions, is generally consistent. A study of middle school students at Montessori schools, for example, found that, compared to their peers at traditional schools matched for socioeconomic status and ethnicity, Montessori children felt more of what Csikszentmihalyi called "flow"—energized, involved, happy, fulfilled—during schoolwork but not in other activities (Rathunde & Csikszentmihalyi, 2005a), and children do move more in Montessori environments than in conventional environments (Byun, Blair, & Pate, 2013). Lillard, Heise, Tong, Hart, and Bray (2017) found relatively more positive feelings about school in Montessori students than in controls, and some new unpublished data from Lillard's laboratory indicate that adults who went to Montessori schools as children reported skipping school less frequently than did students who went to other types of schools, another indicator that they may have enjoyed school more.

Children in authentic Montessori classrooms, as described by Dr. Montessori, showed remarkable concentration on their work.

> *In thousands of schools in every part of the world…little children have demonstrated the capacity of working for long periods of time without tiring, of concentrating in a manner completely remote from the outside world, thus revealing the constructive process of their personalities.* (Montessori, 1956, pp. 158–159)

Similarly, several studies have reported higher executive function in Montessori children (Culclasure, Fleming, Riga, & Sprogis, 2018; Kayılı, 2018; Lillard, 2012; Lillard & Else-Quest, 2006; Phillips-Silver & Daza, 2018) and even in conventionally schooled children who simply used some Montessori materials outside of the classroom (Yildirm Doguru, 2015). Thus, results from research may support Dr. Montessori's description of children in authentic Montessori classrooms concentrating unusually deeply on work they chose and seeming to find joy in their work.

Dr. Montessori believed that because the classrooms allow free interaction with a wide range of classmates, children learn to participate effectively in a heterogeneous social group: "The idea of respecting others, and of waiting one's turn, becomes a habitual part of life which always grows more mature" (Montessori, 1967/1995, p. 224). Dr. Montessori remarked on the kindness of children in classrooms using her system; for example, when someone has an accident (e.g., accidentally breaks a vase), "they all run to help…, encouraging and comforting them" (Montessori, 1967/1995, p. 240). Consistent with these observations, Montessori middle schoolers were more likely to consider their classmates to be friends, and on measures of teacher support and fairness and of classroom order and safety, Montessori middle schoolers reported a better social environment than did matched controls (Rathunde & Csikszentmihalyi, 2005b). Compared to lottery-waitlisted controls, Montessori children showed better social problem-solving skills and (as stated earlier) more positive behavior on the playground (Lillard & Else-Quest, 2006), better theory of mind, and more positive feelings about school (Lillardet. al., 2017). A recent longitudinal study of children in a Turkish Montessori school also showed greater growth across the school year in social competence and emotion regulation than was seen in demographically similar children in a non-Montessori school (İman, Danişman, Akin Demircan, & Yaya, 2017).

In sum, Dr. Montessori believed that authentic Montessori education engenders certain behavioral and social characteristics in children, and research today tends to support her view. The children appear to enjoy work, they concentrate for long periods on their schoolwork, and they are excited by their learning engagements. In addition, they show empathy and respect for their classmates. These characteristics emerge across the developmental planes in the Montessori system, which supports certain human tendencies and allows children to engage in their own self-construction.

Summary and Conclusion

Montessori education is composed of a trinity: the child, the teacher, and the prepared environment. A trained teacher who executes the system as directed, preparing the environment and setting children free, should theoretically observe the outcomes described in the last section. These outcomes are surmised to result in response to a system that meets children's needs at each stage of development, including their overarching human tendencies. The Montessori system involves a grand vision and a unique view of the child and the purpose of education.

Dr. Montessori adjusted the system in response to children throughout her life, but even before her death in 1952, others had begun to implement it differently. Today, *Montessori* is used to describe what happens inside a wide variety of classrooms, and implementation quality differs widely (Debs, 2019). Montessori education evokes strong reactions, both positive and negative. Perhaps this is because when Montessori education is implemented to fidelity, what people see in a classroom looks good, thereby prompting admiration. When it is implemented poorly, people see a classroom that does not function well, and they shun Montessori education rather than understand that the classroom they saw did not implement it properly (Lillard,

2019). Throughout Dr. Montessori's books, one can read clear descriptions of what she considered important aspects of the educational system she developed. Although she surely would have continued to develop that system, we cannot know how. Montessori teacher-preparation organizations and individual schools and teachers have all made changes, adapting the system to a more globalized world, different languages, state and school regulations, and other cultural circumstances that Dr. Montessori had not encountered.

As researchers increasingly study Montessori education, it is useful to understand how individual schools or sets of schools implement the Montessori system relative to some benchmark. It also seems useful for administrators, teachers, and parents to have a description from which to measure variations. Therefore, here we have attempted to describe such a benchmark by synthesizing across Dr. Montessori's books some key features of authentic Montessori education, in the sense of "done in the original way" (*Oxford English Dictionary*, 2019). A summary of the characteristics we discussed is provided in the appendix. Again, we do not claim that the implementation described is necessarily optimal; as noted, throughout her years of work, Dr. Montessori tweaked her system and no doubt would have adjusted it further. By designating what is authentic, people studying Montessori education can include in their analyses school variables (e.g., class size, length of work period) that differ from this authentic implementation and thereby perhaps shed light on what improves the system and what does not. Much more empirical research is needed on the outcomes of this very different but promising educational system.

AUTHOR INFORMATION

†Corresponding Author
Angeline Lillard† is a professor of psychology at the University of Virginia and research partner at the Wildflower Foundation. She can be reached at P. O. Box 400400, Department of Psychology, University of Virginia, Charlottesville, VA 22904-4400, USA. Phone: 01-434-982-4750; Fax: 01-434-979-0411 or Lillard@virginia.edu.

Virginia McHugh is executive director emerita at Association Montessori International / USA and a partner at the Wildflower Foundation where she is a pedagogical coach for the Wildflower Schools in Cambridge, Massachusetts.

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Appendix

Authentic Montessori Elements

This list extracts elements mentioned in Part I (The Environment) and Part II (The Teacher and the Child) of *Authentic Montessori: The Dottoressa's View at the End of Her Life.* It is provided to facilitate detection of variations across Montessori implementations. Elements are listed in the order in which they are discussed in the articles.

Elements of the Environment

Physical Space and Contents

- Prepared
    - Class space and contents are beautiful, inviting, systematically and logically organized (all math together, all language together, etc.)
    - Suited to the child (light furniture children can carry; objects in reach; objects are child sized and usable by children; includes some fragile, breakable objects)
    - Full set of Montessori materials for age group
- Practical Life work is practical; it has a useful aim and is something children see adults do in their culture for real, practical purposes
- Includes no extraneous materials (i.e., materials not described in Montessori's books/lectures, except for culture-specific practical life)
- Only one copy of each material
- Access to nature
- Access to other classrooms

Temporal

- Uninterrupted, long (at least 3 hours in the morning and 2 to 3 hours in the afternoon) work periods every day
- Consistent schedule

Social

- Three-year groupings
- Specific age groupings corresponding to developmental periods: 0–3, 3–6, 6–9, 9–12, 12–15
- 25 or more children in a class
- One teacher, possibly one assistant
- Visitors sit quietly and do not interfere
- The class belongs to the children

Elements of the Teacher

- Attractively dressed
- Inviting and calm manner and voice
- Presents material as very special, wonderful
- Has prepared the environment
- Has undergone rigorous training with personal transformation
- Interferes only when needed
- Observes a great deal
- Shows humility and great respect for children
- Appears aware of entire classroom
- Shows warmth and understanding
- Shows authority

Child Outcomes

- Freely exercise will and judgment
- Enthusiastic
- Imaginative
- Creative
- Like a hive of busy bees
- Show joy, satisfaction, exhilaration in work
- Work independently
- Work calmly
- Work energetically for long period
- Show respect for others
- Wait their turn
- Show empathy (e.g., when others are hurt or break something)

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Designing a Logic Model to Inform Montessori Research

Brooke Taylor Culclasure,[1] Carolyn J. Daoust,[2] Sally Morris Cote,[1] and Susan Zoll[3]

[1]Furman University
[2]University of Kansas
[3]Rhode Island College

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Keywords: *Montessori education, logic models, logic modeling, Montessori research, Montessori evaluation*

Abstract: Montessori education has a long history, but its recent growth in American public schools has led to increased interest in research efforts, particularly in exploring the potential of the Montessori experience to moderate the effects of poverty and in gathering data to evaluate public investment in Montessori schools. To assist research efforts, this paper introduces a comprehen-

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sive visual model, or logic model, that depicts the core components, underlying assumptions, and intended outcomes of the Montessori approach. Logic modeling, which results in a visual representation depicting the connections among a program's inputs, primary activities, and outcomes, is often used in program planning and research to provide a common framework from which to work. Developed over a 3-year period by a collaborative group of experienced Montessori researchers and practitioners, the Logic Model for Montessori Education presented in this paper is a valuable tool for researchers with the potential to lay a foundation across disciplines for future research that is both rigorous and systematic in its measurement of Montessori processes and outcomes.

Dr. Maria Montessori developed the Montessori Method over 100 years ago as a child-centered educational approach based on scientific observations of children from birth to adulthood. While a more complete treatment of the topic is provided later in this article, some of the necessary components for an authentic Montessori program include multiage groupings that foster peer learning, uninterrupted blocks of work time, and guided choice of work activities (Lillard, 2017). In addition, hands-on Montessori learning materials are carefully arranged and available for students' use in an aesthetically tended environment. No extrinsic rewards are offered or grades assigned, and children are encouraged to explore personal interests while widely engaging with others (Lillard, 2017).

In the last two decades, several studies have explored Montessori education and measured implementation and outcomes of participation in both the public and private sectors (Ansari & Winsler, 2014; Brown & Lewis, 2017; Byun, Blair, & Pate, 2013; Culclasure, Fleming, & Riga, 2018; Dohrmann, Nishida, Gartner, Lipsky, & Grimm, 2007; Ervin, Wash, & Mecca, 2010; Hanson, 2009; Lillard, 2012; Lillard & Else-Quest, 2006; Lopata, Wallace, & Finn, 2005; Peng & Md-Yunus, 2014; Rathunde & Csikszentmihalyi, 2005). While often demonstrating findings in favor of Montessori education, many of these studies have significant limitations, such as small sample sizes, questionable authenticity of Montessori implementation, and selection bias. Although a recent randomized controlled trial addressed many of these concerns (Lillard et al., 2017), the limitations of most existing studies and the small quantity of research on Montessori education as a whole relative to other educational models demonstrate the critical need for more-rigorous research focusing on Montessori implementation and the subsequent effect on students, teachers, families, and communities.

One way to address some of the limitations identified in prior studies and help increase the quantity of quality research is to develop a shared understanding of the core components of Montessori pedagogy, its underlying assumptions, and its intended outcomes. While Montessori education is not new, educational researchers have never had a widely accepted, peer-reviewed document or visual aid outlining critical Montessori elements to inform research designs that align with the philosophy and guide the work of those in the field. Thus, researchers and practitioners, recognizing this need, collaborated over the past 3 years to create a comprehensive Logic Model for Montessori Education that depicts the core components, underlying assumptions, and intended outcomes of the Montessori approach. This article further discusses the logic model development process and presents a logic model that has the potential to lay a foundation across disciplines for future research that is both rigorous and systematic in its measurement of Montessori processes and outcomes.

As evident from the more recent, rigorous studies (Culclasure et al., 2018; Lillard et al., 2017), Montessori programs implementing the model with fidelity may effect positive changes in the areas of academic, behavioral, and socioemotional outcomes among participating children. Researchers must continue to explore these and other outcomes in a way that creates a robust body of evidence built from a commonly held understanding of the Montessori approach and the best ways to measure the impact of the approach. The

logic model introduced here can act as a common reference point and a guide for future researchers who aim to contribute to the field regardless of their familiarity with Montessori education.

Why a Logic Model for Montessori Education?

Logic models represent a powerful way to succinctly and clearly communicate the core components of a program or approach to communities of practitioners, researchers, and other stakeholders. The logic model can act as a collective reference point to reconcile conversations across different disciplines and audiences, providing a common language and starting point for understanding best practices and the ways variations in implementation can lead to differences in results. Additionally, they can increase access to information among audiences that do not have expertise in an area by reducing complex narratives and theories to a relatively basic flow diagram that is easy to engage with. In other words, logic models can help individuals see both the forest and the trees, providing an overall picture of what a multifaceted educational approach like Montessori aims to do, while at the same time allowing consideration of how each part of the approach affects the others.

From a research perspective, increasing understanding of core Montessori components and processes may lead to additional, intentional research collaboration. Establishing a shared understanding of the intended outcomes of Montessori education can facilitate a conversation among researchers about how to standardize outcome operationalization and measurement. One of the main limitations to prior research on Montessori education is the lack of comparability between study methodologies and results. At present, Montessori research operates, essentially, in a research vacuum in which data comparison across studies is difficult. Data gathered using the same outcome definitions and measurement tools could be synthesized to create a foundation on which future studies can build, thus enabling researchers to more easily and accurately identify and attribute data inconsistencies to program implementation rather than to outcome measurement.

Modeling the Montessori process also opens the door to multiple research opportunities and pathways. Logic modeling explicates both core program components and processes (that clearly articulate the relationships among program outputs, outcomes, and impacts) in ways that can inform research questions for both process and impact studies. Process evaluations examine the fidelity of program implementation regarding the original program model, while impact evaluations assess whether the program had the intended effect on program participants. A Montessori logic model serves as an invaluable resource because it establishes the standard aspects of an authentic Montessori program and process. Researchers, particularly non-Montessorians, can use this model when designing research studies, allowing them to have a consistent understanding of authentic Montessori education, thereby avoiding potentially flawed research designs and subsequent faulty conclusions.

Logic models are meant to be dynamic resources that change in relation to the needs of program development, implementation, and research. In contrast to a prospective logic model—often used for planning how a new program should be implemented to effect changes—what is presented in this paper is a retrospective logic model for Montessori education. This retrospective model documents the process of authentic Montessori implementation and the intended outcomes for children as those outcomes are currently agreed upon by experts in the field. In addition to increasing understanding of Montessori education and facilitating future rigorous research, this logic model can be used prospectively in updating the Montessori approach as the collective understanding of precisely how Montessori education affects students is strengthened. Additionally, increasing access to the components of the Montessori logic model will help potential adopters weigh its costs and benefits compared to other existing educational models.

The Components of the Logic Model for Montessori Education

Widely used in the worlds of program planning and evaluation, logic modeling is a systematic process of iteratively examining and documenting how and under which conditions a program or approach works. The result is a visual representation that depicts the connections among a program's Inputs/Resources, Activities/Actions, Outputs, the Outcomes the program intends to affect, and the overall, big-picture Impacts. When read from left to right (see Figure 1), logic models present the flow of how a program works over time from the acquisition of resources and funding to the implementation of core activities intended to result in desired changes (W. K. Kellogg Foundation, 2004). Inputs/Resources and Activities/Actions identify planned work, while Outputs, Outcomes, and Impacts trace intended results. The following discussion provides a brief overview of each component of a logic model, along with examples of potential research opportunities specific to Montessori contexts.

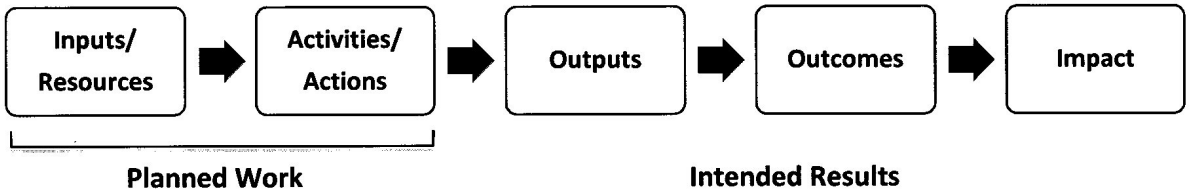

Figure 1. Basic logic model adapted from W. K. Kellogg Foundation, 2004.

Inputs/Resources, according to the W. K. Kellogg's *Logic Model Development Guide*, are the "human, financial, organizational, and community resources a program has available to direct toward doing the work" (p. 2). This encompasses everything from funding and staff to office space, technology, curriculum, and professional development. One input specific to Montessori classrooms is the didactic materials designed to promote students' concentration, independence, and self-correction. Researchers may elect to study an array of instructional materials not found in traditional classrooms that are designed to support a child's learning and development across a host of domains (e.g., language, literacy, math, science, geography). Also, similar to other education research, the actions and dispositions of teachers and their interactions with students are key areas of research to better understand student outcomes within a Montessori context.

Activities/Actions describe how a program uses inputs and resources to achieve program objectives; Activities/Actions are the actual processes and events used to bring about intended results. A critical Montessori activity for achieving authentic implementation is individualized learning within an ordered environment that delivers an integrated curriculum. Researchers could examine the processes embedded within Montessori classrooms that are designed to facilitate integrated curriculum delivery and individualized learning.

Outputs are the measurable, tangible, and direct results of Activities/Actions, usually described in terms of the size, frequency, and/or scope of the services or products delivered or produced. Examples in Montessori education include the number of children participating in Montessori programs who are ready to move to the next level of their education. Note that outputs do not communicate anything about the quality of the direct results from an activity or action.

Outcomes are the intended, short-term changes (i.e., 3 to 5 years) in program participants' "behavior, knowledge, skills, status, and level of functioning" (W. K. Kellogg, 2004, p. 2). Outcomes also can be examined at the systems level in terms of changes in condition or action, such as changes in organizational culture or policy. In Montessori schools, the expected outcomes are participant oriented, focusing on cultivating student behaviors, beliefs, and attitudes. Examples of the student outcomes from participation

in authentic Montessori programs that researchers can examine include increased executive function, creativity, and academic achievement (Brown & Lewis, 2017; Culclasure et al., 2018; Lillard, 2012; Lillard & Else-Quest, 2006; Lillard et al., 2017).

Impacts are long-term and follow the achievement of outcomes over a sustained period (W. K. Kellogg Foundation, 2004). Impacts take 7 to 10 years to manifest and should not be expected to be seen in any significant way in the short term. In the logic model presented in this paper, we propose that children who participate in authentic Montessori programs over a long period of time should develop into physically healthy and mentally and psychologically fulfilled young adults who are highly educated and active participants in their communities.

The Development of the Logic Model for Montessori Education

The process of creating a new logic model is as valuable as the resulting model, just as the process of examining an existing one adds substantial value. When done systematically and with an openness to discovery, engaging with logic models helps researchers surface the assumptions that underlie their logic, assumptions that are critical to consider when trying to understand exactly how or under which conditions a program or educational approach works. A key assumption identified in the logic model presented here is that learner interest in a topic is one of the primary drivers of motivation and learning. If student interest is not piqued through varied learning methods, students will not develop a love of learning or the motivation to become a lifelong learner. Thus, motivation in Montessori classrooms is a prime area for further investigation.

As Martin and Carey (2014) detailed in their article about logic model development, documentation of the model creation and validation process is one of the most valuable aspects of the exercise because of the refined conceptual understanding that emerges. The clarity of thinking that results from building the logic model is critical to the overall success and eventual utility of the model (W. K. Kellogg Foundation, 2004).

As a primary part of the logic model development process, educators and researchers should first collaborate to develop a theory of change to describe the planned intervention that will bring about change in an educational setting. A *theory of change* is "a comprehensive description and illustration of how and why a desired change is expected to happen in a particular context" (Center for Theory of Change, 2017). Dhillon and Vaca (2018) described the theory of change as a roadmap, "providing pathways of outcomes… causally link(ing) inputs and activities to a chain of intended, observable outcomes" (p. 65). Using a backward design strategy to begin this process, stakeholders should first ground the theory of change in proposed outcomes that will be realized after an intervention is implemented. Once the project's outcomes are clearly articulated, the stakeholders may then develop detailed descriptions for each of the project's activities, listing required materials, personnel, and financial or community resources needed to ensure the intervention's success (W. K. Kellogg Foundation, 2017).

The idea for the development of a logic model for Montessori education was first discussed during the convening of the 2015 Montessori Research Working Group in Salt Lake City, UT. Several researchers new to the Montessori field who attended this convening of multidisciplinary researchers expressed the need for a logic model or similar tool to help them understand the core components of Montessori education and to provide a common language for understanding best practices and expected outcomes. Since no such logic model or tool existed, the development of a logic model for Montessori education was added as a priority task for the Montessori Research Working Group, and a Montessori Logic Model subgroup was created to develop the model.

Subsequently, under the leadership of this subgroup, the process included multiple steps over 3 years, with the input of numerous researchers and Montessori content-area experts. Six experienced Montessori teacher educators from both Association Montessori Internationale (AMI) and American Montessori Society (AMS) programs provided in-depth feedback on all sections of the first draft of the model through

an online survey. Next, researchers circulated drafts of the logic model at various Montessori professional conferences and gatherings over the 3-year period and obtained verbal and written feedback from diverse groups of participants. Feedback from researchers, teacher educators, and practitioners resulted in continual refinements to the model through 2019, when it was deemed ready for publication. The timeline in Table 1 outlines the key steps of the process and the associated timeframe. Details about development of each section follow.

Table 1
Timeline of Logic Model Development Activities

Date	Activity
October 2015	The MRWG forms a Montessori Logic Model subgroup. (Westminster College, Salt Lake City, UT)
November 2015	Subgroup begins model development.
March 2016	First draft is completed, shared with subgroup, and revised; drafts are circulated at AMS conference, and feedback is obtained. (Chicago, IL)
November 2016	Subgroup convenes at the MRWG's annual meeting and discusses further revisions and reformatting the model. (Westminster College, Salt Lake City, UT)
Winter 2017	Model is substantially revised (e.g., inputs are shortened, resources, actions, and outputs within and across program levels are added, and assumptions redone as key concepts and applications).
March 2017	Drafts are circulated at AMS conference, and feedback is obtained. (San Diego, CA)
Spring/Summer 2017	Feedback is obtained from Montessori teacher educators individually and at the International Montessori Congress; feedback is then integrated into the model. (Prague, Czech Republic)
September 2017	Infant/toddler level is added to the model.
November 2017	Feedback is provided by MRWG during the annual meeting. (University of Kansas, Lawrence)
December 2017	Montessori infant/toddler teacher educators provide input; section is revised, and input is gathered at the MACTE symposium. (Alexandria, VA)
May 2018	Logic model MRWG subgroup meets virtually, and a final draft is created.
November 2018	Minor revisions are made during MRWG's annual meeting. (University of Kansas, Lawrence)
January–April 2019	Process is documented and all references needed for theory of change are compiled; model is finalized for publication.

Note. MRWG = Montessori Research Working Group; AMS = American Montessori Society; MACTE = Montessori Accreditation Council for Teacher Education.

Inputs Section

The Inputs/Resources section was shortened to Inputs in the Montessori logic model, and an initial list of 10 inputs was created by analyzing Montessori standards across time as outlined by professional Montessori organizations and by identifying areas of consensus (see Table 2). Each input was examined in relation to Dr. Montessori's writings, the writings of Montessori experts, and research on Montessori implementation, as shown in Table 2. Subsequently, the inputs were refined when the model was revised and an eleventh input was added to reflect Montessori education's inclusiveness.

Table 2
Resources for Inputs Section

Source type	Sources
Montessori professional organizational standards	Association Montessori International/USA, 2009; American Montessori Society, 2014; Montessori Australia Foundation Limited, 2012; Montessori Public Policy Initiative, 2015; National Center for Montessori in the Public Sector, 2015
Dr. Montessori's writings	Montessori, 1912/1964; Montessori, 1914/1965; Montessori, 1917/1965; Montessori, 1939/1966; Montessori, 1948/1973; Montessori, 1948/1976; Montessori, 1956/1970; Montessori, 1962/1988; Montessori, 1967/1989; Montessori, 1976; Montessori, 1997; Montessori, 2000; Montessori, 2008
Montessori experts	Boehnlein, 1988; Chattin-McNichols, 1992; Daoust, 2004; Feez, Miller, & Tyne, 2012; Kahn, n.d.; A. S. Lillard, 2017; P. P. Lillard, 1972; P. P. Lillard, 1980; P. P. Lillard, 1996; Pedersen & Pedersen, 2008; Pottish-Lewis, 2011; Rambusch & Stoops, 1992; Standing, 1957/1984
Research on Montessori implementation	Ansari & Winsler, 2014; Byun, Blair, & Pate, 2013; Culclasure, Fleming, & Riga, 2018; Dohrmann, Nishida, Gartner, Lipsky, & Grimm, 2007; Hanson, 2009; Lillard, 2012; Lillard & Else-Quest, 2006; Lopata, Wallace, & Finn, 2005; Peng & Md-Yunus, 2014; Rathunde & Csikszentmihalyi, 2005

Key Concepts, Applications, Overall Impact, and Programming Across Levels Sections

Experienced Montessori practitioners and researchers at all levels examined Montessori professional organizational standards, Dr. Montessori's writings, and the writings of content experts over a 3-year period to create the model's Key Concepts, Applications, and Overall Impact sections, as well as the Programming Across Levels section, as illustrated in Table 3. Expanded programming sections clearly articulate both similarities and differences in resources, actions, and goals across the range of age levels served by Montessori programs.

Table 3
Resources for Key Concepts, Applications, Overall Impact, and Programming Across Levels Sections

Source type	Sources
Montessori professional organizational standards	Association Montessori International/USA, 2009; American Montessori Society, 2014; Montessori Public Policy Initiative, 2015; National Center for Montessori in the Public Sector, 2015
Dr. Montessori's writings	Montessori, 1912/1964; Montessori, 1914/1965; Montessori, 1917/1965; Montessori, 1939/1966; Montessori, 1948/1973; Montessori, 1948/1976; Montessori, 1956/1970; Montessori, 1962/1988; Montessori, 1967/1989; Montessori, 1976; Montessori, 1997; Montessori, 2000; Montessori, 2008
Montessori experts	Boehnlein, 1988; Chattin-McNichols, 1992; Feez, Miller, & Tyne, 2012; Kahn, n.d.; Lillard, 1972; Lillard, 1996; Lillard, 2017; Pedersen & Pedersen, 2008; Pottish-Lewis, 2011; Rambusch, & Stoops, 1992; Standing, 1957/1984

Outputs, Expected Outcomes, and Suggested Assessments Sections

It must be noted that an Outputs section was not included in this more comprehensive logic model because outputs are typically more useful at individual program levels. The Outcomes section of the logic model (renamed Expected Outcomes and Suggested Assessments) includes expectations of enhanced executive function, heightened creativity and self-expression, increased motivation, strong social fluency, and emotional flexibility and advanced self-regulation skills. These outcomes were identified following a comprehensive review of the literature outlined in Table 3. The Suggested Assessments section was added so that appropriate and commonly used measures are listed in the logic model for each expected outcome. Instruments are organized by the types of outcomes they are designed to measure in Table 4.

These instruments represent examples of assessment tools across the breadth of nonacademic and academic outcomes expected from Montessori experience using measures that are also appropriate for use in non-Montessori contexts. These suggested assessments, while not exhaustive, represent a compilation of instruments recommended by experts in research, measurement, and assessment, including instruments previously used in Montessori studies with reasonable success. Table 5 summarizes specific recent studies according to which measure was incorporated.

Table 4
Suggested Assements Organized by Expected Outcomes

Expected outcomes	Suggested assessments
Executive function	Carlson & Zelazo, 2017; Gershon & Wagster, 2010a; Gioia, Isquith, Guy, & Kenworthy, 2000; Ponitz, McClelland, Matthews, & Morrison, 2009
Creativity and self-expression	Lubart, Besançon, & Barbot, 2011; Meisels, Jablon, Dichtelmiller, & Marsden, 2015; Torrance, 2010
Motivation	ACT, 2012
Social fluency and emotional flexibility	Bronson, 2000; Gershon & Wagster, 2010b; Gresham & Elliott, 2008; Squires, Potter, & Bricker, 1995
Self-regulation	Gershon & Wagster, 2010c; LeBuffe, Shapiro, & Robitaille, 2018
Academic performance	Dunn & Dunn, 2007; Gershon & Wagster, 2010d; Janus, Offord, & Mustard, 1999; Bracken, 2006; NWEA, 2019
Cognition and general development	Gershon & Wagster, 2010a; Schrank, McGrew, & Mather, 2014; Squires, Potter, & Bricker, 1995

Table 5
Studies Organized by Suggested Assessments Used

Suggested assessment	Studies
ASQ-3	Tobin et al., 2015
BRIEF	Bagby, Barnard-Brak, Sulak, Jones, & Walter, 2012; Culclasure, Fleming, & Riga, 2018
EPoC	Cossentino & Brown, 2014; Culclasure et al., 2018
HTKS	Culclasure et al., 2018; A. S. Lillard, 2012; A. S. Lillard, 2017; A. S. Lillard et al., 2017; Lillard & Heise, 2016
MEFS	Cossentino & Brown, 2014; Culclasure et al., 2018
NIH Cognition Battery	Phillips-Silver & Daza, 2018
NIH Flanker	Culclasure et al., 2018; Phillips-Silver & Daza, 2018
Student Record Database	Culclasure et al., 2018

SSWH	Ervin et al., 2010
TTCT	Besançon, Lubart, & Barbot, 2013
WJ III/IV	Lillard & Heise, 2016

Note. ASQ-3 = Ages & Stages Questionnaire; BRIEF = Behavior Rating of Inventory of Executive Function; EPoC = Evaluation du Potentiel; HTKS = Head-Toes-Knees-Shoulder Task; MEFS = Minnesota Executive Function Scale; NIH Cognition Battery = NIH Toolbox Cognition Battery; NIH Flanker = NIH Toolbox Flanker Inhibitory Control & Attention Test; SSWH = Social Skills and Work Habits; TTCT = The Torrance Tests of Creative Thinking; WJ III/IV = Woodcock-Johnson III/IV.

The Logic Model for Montessori Education

Figure 2 is the culmination of the work outlined in the previous sections and presents a graphic display of critical components of the logic model. It is important to note that this logic model is a living document, and it is expected that subsequent versions of the logic model, supported by the most current research, will be published in the future. A downloadable version of the logic model and its associated references is available in the Supplementary Materials.

Conclusions and Future Directions

Regarding future directions and considerations for subsequent versions of the logic model, more work should be done in several areas. For example, peace education and some aspects of social justice are deeply rooted within Montessori pedagogy (Debs, 2019; Duckworth, 2008). Therefore, an expanded treatment of the potential of Montessori as a vehicle to ensure equitable learning opportunities is warranted. Such an examination will require deeper consideration of bias, equity, and human rights in all aspects of the Montessori approach to ensure that all children are able to equally thrive and benefit from Montessori education.

The logic model presented in this paper is a valuable tool for researchers seeking to study Montessori education, as it has the potential to lay a foundation across disciplines for research that is both rigorous and systematic in its measurement of Montessori processes and outcomes. While constant work is required to ensure the logic model remains updated and reflects the most current research, this first version provides a solid foundation from which researchers and practitioners can work and continue to build.

AUTHOR INFORMATION

†Corresponding Author

Brooke Culclasure† is research director of Furman University's Richard W. Riley Institute and can be reached at brooke.culclasure@furman.edu.

Carolyn Daoust is a research associate at the University of Kansas Center for Montessori Research.

Sally Morris Cote is the Richard W. Riley Institute at Furman University's director of Planning and Evaluation Capacity Building.

Susan Zoll is an associate professor in elementary education at Rhode Island College as well as the director of the Institute of Early Childhood Teaching and Learning at Rhode Island College.

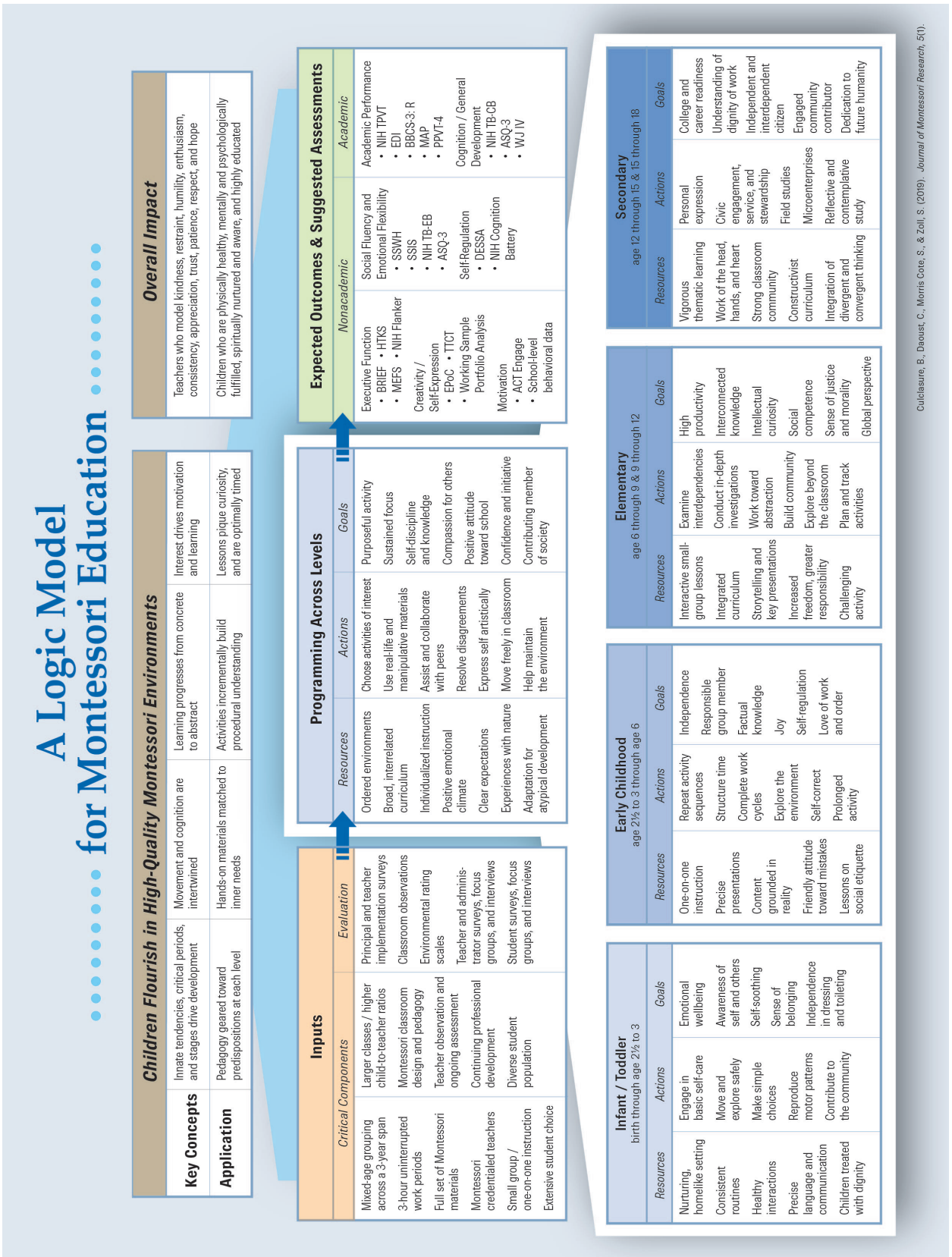

Figure 2. A Logic Model for Montessori Education.

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Developing Instruments to Measure Montessori Instructional Practices

Angela K. Murray, Carolyn J. Daoust, and Jie Chen

University of Kansas

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Abstract: Researchers who study any intervention must rule out potential alternative explanations for their results by establishing that the program being investigated is implemented with fidelity. Various instructional practices are attributed to the Montessori Method because the term is not legally protected, meaning any school can say it is Montessori regardless of the degree to which it adheres to practices generally understood to represent Montessori education. Researchers have used a variety of tools to measure the fidelity of Montessori environments they study, but most of these tools lack an extensive psychometric foundation or are labor intensive, requiring in-person observation. The purpose of this study was to examine the psychometric properties of instruments that were developed to measure Montessori implementation through Early Childhood (EC) and Elementary (EL) teachers' reported instructional practices. Findings supported three hypothesized dimensions of Montessori implementation (structure, curriculum, and freedom), which worked fairly well in describing practices. While the properties of these instruments are promising and provide preliminary supporting evidence, results of this analysis suggest further refinement of the items in these instruments is necessary with larger and more diverse samples. While we do not suggest that these are finalized tools, we believe they provide a valuable starting point that is a vast improvement over the requirement of investigators to develop their own instruments as part of each Montessori study they design. The authors hope other researchers will incorporate these instruments into their studies to help build a robust body of evidence supporting their use.

Since the Montessori name is not legally protected, any school can use the term regardless of the degree to which they follow the principles of the Montessori philosophy and Method (Lillard & McHugh, 2019; MontessoriPublic, 2019). The inconsistency in what is called Montessori in schools around the world and a lack of an objective definition create confusion in public opinion as well as challenges in the field of education research (Culclasure et al., 2019). While much consensus exists within and across Montessori organizations on essential elements for authentic Montessori programs (AMI, n.d.; AMS, 2018; Culclasure Daoust, Cote, & Zoll, 2019; MPPI, 2015), no widely accepted instrument exists for assessing the degree to

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which these environments incorporate Montessori practices. Therefore, this study's purpose was examining the suitability of instruments assessing Montessori Early Childhood (EC) and Elementary (EL) teachers' instructional practices.

Review of Literature

Fidelity evidence is crucial for demonstrating adherence to a model being investigated, allowing for consistency and replication. Without it, conclusions are limited because it is impossible to rule out confounding factors (Vartoli & Rohs, 2009). Maria Montessori developed her Method of education more than a century ago initially to demonstrate that education of children with disabilities was possible. Today approximately 20,000 Montessori schools exist worldwide; 4,500 exist in the United States, including roughly 500 public programs (NAMTA, 2015; NCMPS, 2015). While the research base has grown along with proliferation of Montessori schools in recent years, rigorous evidence of Montessori effectiveness is limited (Marshall, 2017; Lillard et al., 2017). A consistent challenge is providing evidence of authenticity of the programs being examined due to numerous interpretations of what constitutes Montessori education (Wentworth, 1999).

Fidelity Measurement

Before discussing the issue of fidelity in the context of Montessori education, we provide an overview of the concept of fidelity measurement. In simplest terms, Century, Rudnick, and Freeman (2010) contend that "programs consist of essential features that must be measured to determine whether a program is present or not" (p. 201). In education research, fidelity measurement is a means of documenting that an intervention was implemented as planned. Researchers who are studying any intervention must examine issues of fidelity in order to establish internal validity as a means of ruling out potentially confounding factors or alternative explanations for the resulting impacts that are found (Feely, Seay, Lanier, Auslander, & Kohl, 2017; Mowbray et al., 2003; Stains & Vickrey, 2017). Well-developed fidelity measures can improve study power as well (Mowbray et al., 2003). Issues of fidelity can also have impacts for program administration, but that is beyond the scope of this discussion.

Mowbray and colleagues (2003) outline three steps in the process of the construction of a valid fidelity index. First, they suggest that developers must identify possible critical components of the program, which are often based on input from experts or documented explicit descriptions of the program and includes sources for each of the identified components. However, the researchers caution that:

> *. . . there is little illusion that a practical fidelity instrument can measure [the most significant program components] comprehensively. In many instances, the elements of a fidelity measure serve, in effect, as indicators of the model's design and operations—key program features that relate strongly to positive outcomes for those served—but do not necessarily include all such features, nor any features in the depth suggested by a fully explicated program theory*. (p. 330)

Second, Mowbray and colleagues (2003) advise that developers collect data to measure the components, ideally using multiple data sources. Third, they indicate developers should examine the critical components in terms of their psychometric properties, including reliability and validity.

Following a process similar to Mowbray and colleagues' (2003) three steps, Feely and colleagues (2017) outline a process in their "Field Guide to Fidelity Measurement":

1. Defining purpose and scope
2. Identifying essential components
3. Developing the tool

4. Monitoring fidelity during study
5. Using fidelity ratings in analysis

The same process is undertaken in the present study.

A common way to conceptualize the critical components of fidelity in developing a measurement tool is through considering *structural components* and *process components*. Structural components are generally considered features that relate to the framework of the intervention, while process components relate to how the intervention is implemented with respect to teachers and students (Century et al., 2010; Mowbray et al., 2003; Stains & Vickrey, 2017).

In examining the literature regarding development of fidelity instruments, Mowbray and her team (2003) identify five approaches often used to analyze their psychometric properties; one of these is an examination of the internal structure of the empirical critical component data through approaches such as confirmatory factor analysis (CFA), cluster analysis, and/or internal consistency reliability. The use of a CFA approach in analyzing the structure of critical component empirical data is supported by other authors as well (Century et al., 2010; Stains & Vickrey, 2017). The present study follows these recommendations through CFA as well as item response theory approaches to allow for a better understanding of the internal structure of the data gathered through the measures being piloted.

When using fidelity measures in research, some tools calculate total fidelity scores and/or incorporate specific scoring interpretation and cut-points for defining acceptable levels of overall adherence to the intervention model. Century and colleagues, however, follow a process that examines gradations of implementation accounting for a range of possible critical components, in particular combinations considering their impact on student outcomes, in order to understand the roles that particular critical components play (Century et al., 2010; Stains & Vickrey, 2017). As a first attempt at developing a fidelity measure for Montessori education, the present study follows Century and colleagues' approach in allowing for a range of possible critical component scores without establishing ranges of acceptable performance. Such values may be developed through subsequent use of the instruments in further research studies.

In conclusion, it is important to remember that, while valid fidelity evidence is expected in research examining the effectiveness of interventions, issues of adaptation versus strict replication are also being explored in the field of education. Authors recognize that often very real situational considerations lead to the necessity or even desirability of adaptation that stand in direct contrast to the kinds of implementation purity that make for the strongest research designs (Mowbray et al., 2003; Century et al., 2010; Stains & Vickrey, 2017). In the context of Montessori education, Dr. Mira Debs' 2019 book, *Diverse Families, Desirable Schools: Public Montessori in the Era of School Choice,* highlights how some efforts throughout history to preserve Montessori fidelity inadvertently limited its expansion in public programs that serve more diverse communities. She specifically references the number of teacher training programs operating independently from universities and the expense of Montessori materials as examples. Therefore, any discussion about Montessori fidelity must acknowledge potential impacts of focusing too narrowly on instructional practices without considering the larger context.

Measuring Montessori Instructional Practices

Researchers have used a variety of tools in attempts to measure the fidelity of Montessori environments they study, but most of these tools lack an extensive psychometric foundation and are labor intensive, requiring in-person observation. The instrument used in the South Carolina statewide Montessori study required trained Montessori educators to assess environments (Riley Institute for Education Policy, 2016). Lillard (2012) measured time spent with traditional Montessori materials as a gauge of authenticity. The issue of implementation fidelity is critical for Montessori education in particular because research shows that higher-fidelity programs are associated with better student outcomes (Lillard, 2012). So, a more robust and efficient method of assessing fidelity would be valuable.

Daoust (2004) examined Montessori EC program implementation and classroom practices through a cluster analysis identifying four groups of teachers: (1) traditional following strict Montessori practice, (2) contemporary including some elements of authentic Montessori but to a lesser degree, (3) blended incorporating some traditional and Montessori practices, and (4) explorative incorporating traditional and Montessori practices but reflecting an autonomy-supporting orientation to classroom management.

Classroom practice variety is also evident in research conducted by Daoust and Suzuki (2014), who surveyed 444 public elementary Montessori teachers. Cluster analysis was used to classify the Montessori educators into meaningful groups. Post-typological analyses indicated significant differences between the identified clusters. For example, the three identified clusters differed by work period length and the extent to which children could choose their snack time. Their findings highlight an association between teacher and school characteristics and the enactment of authentic practices as useful for establishing and sustaining high-quality Montessori elementary programs in the public sector.

In summary, a high-quality, efficient fidelity instrument for Montessori education is needed and would provide the opportunity to improve the quality of future research studies on instructional practices and Montessori outcomes. The purpose of this study was to examine the suitability of items included in instruments assessing Montessori EC and EL teachers' instructional practices.

Methods

Instruments

Following the steps recommended by Mowbray and colleagues (2003), we first developed items for the Teacher Questionnaires of Montessori Practices based on extensive review of original works of Maria Montessori along with recommendations of respected Montessori organizations, writings of Montessori experts, and results from prior research examining Montessori implementation. Broad areas of focus organizing the individual items in the instruments align with inputs described in the Logic Model for Montessori Education proposed by Culclasure and colleagues (2019). Documentation of specific sources supporting the inclusion of each item in the instruments is provided in Appendices B and C. Because instructional practices differ substantially between student age groups in Montessori classrooms, 3- to 6-year-olds in EC, and 6- to 12-year-olds in EL, a separate questionnaire was developed for the EC level and the EL level, which represent the bulk of Montessori classrooms (NCMPS, 2015).

Experienced Montessori teachers and teacher educators as well as psychometricians with significant experience in instrument development provided feedback on draft versions of the Teacher Questionnaires of Montessori Practices, and earlier versions were piloted with another sample of teachers. Based on a review of pilot study results, revisions were made resulting in the instruments that were tested in this study. The revised questionnaires were reviewed by an expert panel of Montessori teacher educators, including 10 from the EC level and 13 from the EL level.

A total of 26 items rated on a 4-point Likert scale ranging from strongly disagree (1) to strongly agree (4) were included in the EC instrument, and 33 similarly rated items were included in the EL instrument. Appendix A includes the items as they were administered to participants. In addition to the items for fidelity analysis, we gathered information on professional characteristics of teachers, classroom descriptions, and teacher demographics.

Procedure

The two instruments were programmed using the Qualtrics survey platform for email distribution that contained anonymous links for potential participants. Each instrument required an average of 15 minutes to complete. Approval for this study was obtained from the University of Kansas Human Subjects Committee.

Participants

Two groups of participants provided data for this analysis. In the first group, Montessori teachers at the EC and EL levels in an existing database maintained by Montessori Compass, an online record-keeping system, were invited to participate in the study. Survey links were emailed by the company to 6,033 subscribers and were also posted on the company's Facebook page to encourage participation. Almost half of the emails were opened (n = 2,776); 15 percent of those who opened the email responded (n = 407). Some teachers could have been from the same school, but it is not possible to account for this possibility because of the anonymous nature of the recruitment and response.

In addition to the participants recruited from Montessori Compass, the authors posted a link in the Montessori Research Interest Facebook group to invite EC and EL teachers to participate. This Facebook group, at www.facebook.com/groups/508077912670003, is a forum for both professionals and laypeople to share research, thoughts, and opportunities; the group has more than 7,000 members.

Incorporating these additional participants and removing participants who failed to respond to any items brought the final sample to 242 for the EC data set and 170 for the EL data set. Only teachers, co-teachers, assistants, and interns from both sample sources were included in the analysis, which excluded school administrators and teachers of special subjects such as music and physical education. As outlined in Table 1, the majority of participants were lead teachers, worked in private schools, had Montessori credentials, had a median of 7 years of teaching in Montessori classrooms, and were White, non-Hispanic. Although striking, this lack of diversity and prevalence of employment in private schools are typical of a recognized issue for Montessori education (Debs, 2016). Current estimates indicate that roughly 80 percent of Montessori programs are in private schools, so the preponderance of teaching professionals from private schools in our sample is not surprising (NCMPS, 2019).

Analysis

We considered the common approach of conceptualizing the critical components of instructional practices as *structural* and *process* for our Montessori fidelity model (Century et al., 2010; Mowbray et al., 2003; Stains & Vickrey, 2017). We decided to separate the process component into two subcomponents, curriculum and freedom, because freedom represents a fundamental aspect of Montessori education that could be conceptualized as functioning differently than other elements of Montessori practice. As a result, we hypothesized three constructs to represent the concept of Montessori fidelity based on the fidelity literature combined with previous research and a thorough review of the literature regarding Montessori philosophy and practice (Culclasure et al., 2019; Daoust, 2004; Daoust & Suzuki, 2014). Although individual indicators differ, these three factors included classroom structure, curriculum, and children's freedom and apply both to EC and EL Montessori practice.

We provide a basic outline of our analysis procedures and results here in the main body of the article (see Figure 1); more details are available in the Technical Appendix for those who are interested. First, we used SPSS (Version 24) to conduct Pearson correlation analysis and obtained the correlation coefficients among items within each construct, comparing the results to a previous pilot study. Next, using the "lavaan" package (version 0.6-2) in R (Rosseel, 2012), we conducted confirmatory factor analysis (CFA) loading all items onto three constructs based on theory (i.e., structure, curriculum, and freedom). Factor analysis is often used in psychometric analysis of instruments providing validity evidence for hypothesized constructs (Floyd & Widaman, 1995). The robust maximum likelihood (MLR) estimation method was used. Discussion of the reasoning behind selecting this method as well as issues of multivariate normality and missing data are provided in the Technical Appendix.

Finally, using the mirt package in R (Chalmers, 2012), we conducted unidimensional item response theory (IRT) calibration with graded response models (GRM) to estimate each item's parameters and plotted the item characteristics curve (ICC) for each of the items within each of the three constructs (see details

Table 1

Participant Descriptions

	EC %	**EL %**
Total	*N* = 242	*N* = 170
Role in classroom (multi-response)		
-Lead teacher	79	72
-Co-teacher	15	13
-Assistant	10	3
-Intern	3	1
Type of school		
-Private	80	67
-Public	20	33
Montessori credential		
-Yes	82	76
-No	5	6
-In progress	11	12
-At another level	3	6
Race (multi-response)		
-American Indian or Alaska Native	2	1
-Asian	8	5
-Black or African American	6	3
-Native Hawaiian or Other Pacific Islander	<1	1
-White	78	88
-Prefer not to answer	8	7
Hispanic ethnicity	8	6
Female	95	90
Years Montessori teaching		
-Mean	10.57	10.42
-SD	9.19	8.09
-Median	7	7

in Technical Appendix). These items have no single correct answer, so we used IRT to describe the data with the rating scale measuring degrees of agreement with Montessori instructional practices. We estimated b-parameters (i.e., item difficulty) and a-values (i.e., item discrimination) because IRT is based on the concept that it is possible to separate a person's responses to items from their underlying performance on the latent construct the scale is measuring (Hambleton, Swaminathan, & Rogers, 1991). In this case, ability would represent a teacher's degree of Montessori fidelity. For the purposes of the IRT analysis, we collapsed all responses of 1 and 2 because there were two items for which no participants responded with 1, and across almost all items the proportion of 1 responses was very small.

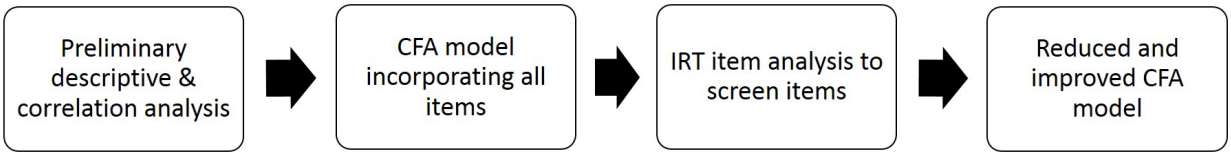

Figure 1. Analysis process for development of instruments.

Results

Descriptive results from all items initially examined are provided in Table 2 for EC and Table 3 for EL where stronger levels of agreement would be expected to reflect higher-fidelity Montessori practice. As mentioned previously, agreement tends to be skewed toward the positive end of the scale for most items. Further analysis of the univariate skewness and kurtosis of these items is provided in the Technical Appendix.

Initial CFA model results incorporating all items suggested promise with all but two of the paths significant, but model fit statistics indicated improvement was possible with details provided in the Technical Appendix. Therefore, we used IRT to identify items that could be removed from the scale to improve the instruments.

Based on results of IRT analysis, we dropped items with an inversed ICC (i.e., lower ability has a higher probability of agreement) or a flat ICC (i.e., suggesting that items do not discriminate among participants). Table 4 shows the number of items before and after eliminating items from each data set. Although with 242 EC and 170 EL participants, sample sizes for these two groups are smaller than typically recommended for these analyses, the models converged and results suggest relatively strong model fit, particularly in the improved model, as evident in the Technical Appendix (Lewis, 2017).

IRT analysis produced item parameters shown in Tables 5 and 6 with model fit statistics available in the Technical Appendix. The b-mean parameters for the retained items range from −0.025 to −2.55, and the a-parameters range from 0.63 to 4.22. We can say that the larger the b-mean is, the more people selected the lower ends of the scale representing lower fidelity; the smaller the b-mean is, the more people selected the higher ends of the scale representing higher fidelity. By looking at the b-mean value, we can tell if more people agree or disagree on the statement. A larger a-value indicates the item is more discriminant, meaning the responses are more spread to distinguish different degrees of Montessori practices. A smaller a-value indicates the opposite (Edelen & Reeve, 2007).

After deleting problematic items, we ran a CFA analysis on the reduced set of items for both EC and EL. While the benefit of using a CFA approach is the ability to quantify model fit, there is not one generally accepted measure to evaluate the results. Instead, it is suggested that multiple fit indices be used (Thompson, 2004). We examined the most commonly reported indices: (a) chi-square (X^2), (b) comparative fit index (CFI), and (c) root mean square error of approximation (RMSEA). Results from the initial CFA with all items included are provided in Table 7 along with the improved model fit statistics for comparison purposes.

A statistically significant chi square indicates that the model is not effectively reproducing the observed patterns of relationships. Our final CFA results showed a nonsignificant chi square at an alpha level of .05 for the EC sample but a significant chi square for the EL sample. However, our CFI values for the EC and EL improved models were both above .90, indicating excellent fit, and we found RMSEA values well below .08, which is considered indicative of an adequate model (Browne & Cudeck, 1993). The Technical Appendix contains details regarding the factor loadings both before and after items were removed from the analysis. Therefore, we conclude that the models for each age level with three latent factors fit the data to an acceptable degree. Although the model fit for the three-construct CFA model outperformed that of the

Table 2

Response Proportion on EC Items by Construct (some items shortened for space)

Item #	Item	1	2	3	4	Missing
Structure						
Q4_02	At least 3 age levels.	0.07	0.04	0.06	0.83	0.00
Q4_06	Children give lessons to one another.	0.05	0.06	0.38	0.51	0.00
Q4_08	At least 25 children typically attend each day.	0.35	0.14	0.17	0.34	0.00
Q6_01	Observation is used for daily lesson planning.	0.03	0.05	0.32	0.59	0.01
Q6_02	Children's activities are recorded each day.	0.05	0.09	0.31	0.54	0.00
Q6_03	There is a 3-hour uninterrupted work period.	0.07	0.16	0.35	0.42	0.01
Q6_04	Lessons are mostly given to individuals.	0.03	0.12	0.35	0.50	0.00
Q7_07	Are evenly spread across at least a 3-yr age span.	0.10	0.14	0.26	0.49	0.00
Curriculum						
Q4_01	A full set of Montessori materials is available.	0.02	0.05	0.16	0.76	0.00
Q4_05	Art materials are available all day.	0.02	0.05	0.15	0.78	0.00
Q4_07	A polishing activity is available.	0.08	0.06	0.20	0.65	0.00
Q6_05	Breakable materials are available.	0.01	0.03	0.08	0.87	0.01
Q6_06	Classroom books feature realistic stories.	0.02	0.07	0.35	0.56	0.00
Q6_07	Children regularly prepare food.	0.10	0.16	0.29	0.45	0.00
Q6_08	Older children do golden bead addition.	0.07	0.06	0.19	0.67	0.01
Q7_03	Care for classroom plants.	0.05	0.04	0.22	0.69	0.00
Q7_04	Care for classroom animals.	0.20	0.11	0.20	0.47	0.02
Q7_08	Walk on the line carrying objects.	0.11	0.11	0.28	0.50	0.01
Q7_09	Regularly use the Montessori bells.	0.41	0.17	0.22	0.18	0.01
Q7_10	Garden is in a designated area.	0.15	0.10	0.26	0.48	0.01
Freedom						
Q4_03	Children may choose to skip circle time.	0.14	0.21	0.39	0.26	0.00
Q4_04	Snack is a self-serve activity.	0.06	0.05	0.10	0.79	0.00
Q7_01	May choose to work alone or with others.	0.00	0.04	0.22	0.73	0.01
Q7_02	Decide where they will work.	0.00	0.03	0.21	0.75	0.02
Q7_05	Choose their work/activities.	0.00	0.02	0.23	0.74	0.01
Q7_06	Determine how long to work with an activity.	0.01	0.02	0.24	0.72	0.01

Note: All items were included.

one dimension of Montessori fidelity, model fit was improved when the factors were allowed to correlate, as shown in Table 8. More details about the CFA analysis, including the significance of the paths, are provided in the Technical Appendix.

Finally, internal consistency of the refined total scales and their respective subscales was measured using Cronbach's alpha. Cronbach's alpha is commonly reported for studies of instrument validity because it provides information about the degree to which all the items in a scale measure the same construct. Simply stated, Cronbach's alpha has a range of possible values between 0 and 1 and can be thought of as the correlation of a scale with itself. The total EC scale with 18 items had a coefficient alpha of .82 with the 6 struc-

Table 3

Response Proportion on EL Items by Construct (some items shortened for space)

Item #	Item	1	2	3	4	Missing
Structure						
Q4_01	Children are in at least 3 grade levels.	0.06	0.02	0.05	0.87	0.00
Q4_03	All children go out for lunchtime recess.	0.05	0.02	0.15	0.77	0.01
Q4_06	Most lessons last 15 minutes or less.	0.05	0.12	0.46	0.36	0.00
Q4_07	Problem-solving for off-task behavior.	0.02	0.06	0.34	0.58	0.01
Q4_08	1-on-1 meetings at least every 2 weeks.	0.09	0.18	0.32	0.40	0.00
Q6_02	Observation used for daily lesson planning.	0.01	0.06	0.42	0.50	0.01
Q6_05	Children record activities in work journals.	0.05	0.08	0.15	0.71	0.01
Q6_06	There is a 3-hour uninterrupted work period.	0.05	0.06	0.26	0.63	0.01
Q6_07	Children give lessons to one another.	0.01	0.08	0.48	0.42	0.01
Q6_08	Most lessons given in groups of 2-5.	0.03	0.09	0.38	0.49	0.01
Curriculum						
Q4_04	Spelling exercises are individualized.	0.05	0.05	0.41	0.47	0.01
Q4_10	Art materials are available all day.	0.05	0.11	0.24	0.60	0.00
Q4_11	Children correct their own work.	0.02	0.12	0.54	0.32	0.01
Q4_12	Full set of large geography charts.	0.11	0.09	0.24	0.56	0.00
Q6_01	Great Lessons/Stories are given each fall.	0.05	0.07	0.23	0.64	0.01
Q6_03	Use human fundamental needs charts.	0.07	0.12	0.37	0.43	0.01
Q6_09	Most instruction with Montessori materials.	0.02	0.04	0.24	0.69	0.01
Q6_10	Children regularly prepare food.	0.17	0.21	0.26	0.36	0.01
Q7_07	Make history timelines.	0.06	0.17	0.39	0.36	0.01
Q7_08	Create their own math problems.	0.08	0.28	0.41	0.22	0.01
Q7_09	Repeat Montessori science experiments.	0.04	0.21	0.34	0.40	0.01
Q7_10	Have access to full set of Montessori materials.	0.02	0.02	0.21	0.74	0.01
Q7_11	Take part in community service projects.	0.04	0.14	0.42	0.39	0.01
Freedom						
Q4_02	Children decide when to have snack.	0.06	0.08	0.14	0.72	0.00
Q4_05	Small groups do “going out” excursions.	0.24	0.18	0.24	0.33	0.02
Q4_09	Children make classroom rules/guidelines.	0.03	0.02	0.19	0.76	0.00
Q6_04	Children create room maintenance system.	0.02	0.06	0.40	0.51	0.01
Q7_01	Do research based on interests.	0.01	0.03	0.35	0.61	0.01
Q7_02	Choose their work/activities.	0.01	0.02	0.41	0.54	0.02
Q7_03	Decide if they will do a follow-up activity.	0.06	0.21	0.48	0.24	0.01
Q7_04	Determine how long to work with activity.	0.01	0.04	0.39	0.55	0.02
Q7_05	Decide where they will work.	0.01	0.04	0.27	0.67	0.01
Q7_06	May choose to work alone or with others.	0.01	0.02	0.18	0.78	0.01

Note: All items included.

Table 4

Number of Items by Construct

Construct	EC		EL	
	Original number of items	Final number of items	Original number of items	Final number of items
Structure	8	6	10	7
Curriculum	12	8	12	9
Freedom	6	4	11	6
Total items	26	18	33	22

ture items at .62, 8 curriculum items at .75, and 4 freedom items at .80. The total EL scale of 22 items had a coefficient alpha of .88 with the 7 structure items at .69, 9 curriculum items at .80, and 6 freedom items at .68. Acceptable values of alpha range from .70 to .95. Cronbach's alpha of the total scale for both EC and EL is fairly high, and most subscales approach the acceptable range. The lowest value of Cronbach's alpha is from the structure subscale for EC at .62. The values of alpha for subscales are understandably lower than that for the total scale because there are fewer items in each of the subscales (Tavakol & Dennick, 2011).

Table 5

EC Item Parameters by Construct

Item #	a	b1	b2	b-mean
Factor 1. Structure				
Q4_01	0.72	−3.07	−0.21	−1.64
Q6_01	1.40	−2.39	−0.47	−1.43
Q6_02	1.16	−2.12	−0.26	−1.19
Q6_03	0.85	−1.78	0.38	−0.70
Q6_04	1.01	−2.25	−0.10	−1.17
Q7_07	1.10	−1.27	0.07	−0.60
Factor 2. Curriculum				
Q4_01	1.10	−3.03	−1.37	−2.20
Q4_07	1.44	−1.71	−0.63	−1.17
Q6_06	0.63	−4.54	−0.56	−2.55
Q6_07	1.29	−1.12	0.14	−0.49
Q6_08	1.19	−2.04	−0.83	−1.43
Q7_03	1.44	−-2.33	−0.89	−1.61
Q7_08	1.46	−1.40	−0.12	−0.76
Q7_10	0.88	−1.52	0.02	−0.75
Factor 3. Freedom				
Q7_01	1.37	−3.07	−1.03	−2.05
Q7_02	2.07	−2.74	−0.93	−1.84
Q7_05	4.22	−2.25	−0.71	−1.48
Q7_06	1.41	−3.15	−0.94	−2.05

Table 6

EL Item Parameters by Construct

Item #	a	b1	b2	b-mean
Factor 1. Structure				
Q4_07	0.79	−3.47	−0.48	−1.974
Q4_08	0.92	−1.23	0.53	−0.350
Q6_02	1.37	−2.40	0.01	−1.193
Q6_05	0.66	−3.08	−1.51	−2.294
Q6_06	1.50	−1.88	−0.46	−1.171
Q6_07	0.92	−2.76	0.43	−1.164
Q6_08	1.68	−1.65	0.03	−0.811
Factor 2. Curriculum				
Q4_11	0.83	−2.43	1.06	−0.688
Q6_01	1.08	−2.17	−0.69	−1.433
Q6_03	2.07	−1.12	0.21	−0.458
Q6_09	1.25	−2.69	−0.85	−1.773
Q6_10	1.20	–0.52	0.62	0.047
Q7_07	1.73	−0.98	0.48	−0.251
Q7_09	1.89	−0.90	0.32	−0.291
Q7_10	1.71	−2.59	−0.94	−1.765
Q7_11	1.26	−1.54	0.42	−0.560
Factor 3. Freedom				
Q4_02	0.71	−2.68	−1.42	−2.05
Q4_09	1.59	−2.43	−1.04	−1.73
Q7_01	1.12	−3.44	−0.53	−1.98
Q7_02	1.61	−2.84	−0.20	−1.52
Q7_04	1.82	−2.30	−0.18	−1.24
Q7_05	1.75	−2.37	−0.65	−1.51

Discussion

Results suggest that three hypothesized dimensions of Montessori fidelity (structure, curriculum, and freedom) work well in describing EC and EL practices. Furthermore, items in the final analysis did a reasonable job of reflecting the performance of this sample of Montessori teachers on these dimensions. However, further study is necessary before recommending use of these instruments as vetted tools for widespread use in research projects. While promising, results suggest that further refinement of items in these fidelity instruments with larger and more diverse samples is necessary.

Limitations of this study include small sample sizes and relatively homogeneous samples of Montessori teachers, which could introduce bias, so it will be important to expand future applications of these instruments to strengthen the evidence for its use in a variety of contexts and with larger and more representative samples. Specifically, since our models were modified post hoc based on this particular sample, sampling bias could limit the replicability of these results. Furthermore, these instruments are based on

Table 7

CFA Model Fit Comparison: Initial Model vs. Improved Model

Data	Model	χ^2	df	*p*	RMSEA	RMSEA 90% CI	CFI
EC	Initial	266.63	192	<.001	.04	.028-.051	.934
	Improved	100.62	83	.09	.03	.000-.047	.972
EL	Initial	459.14	324	<.001	.05	.039-.059	.889
	Improved	172.69	134	.01	.04	.021-.057	.947

teacher self-report, which will require further research to confirm alignment with actual observed practices. Next steps in investigating the validity of these fidelity measurement tools for research purposes involve incorporating the scales into studies of other aspects of Montessori education to investigate relationships with these constructs as well as outcome measures while understanding that additional evidence to support the appropriateness of using this tool is necessary at this point in its development.

Table 8

Covariance Between Latent Variables in the Improved CFA Model for EC and EL Data

	EC			EL		
Constructs	**1**	**2**	**3**	**1**	**2**	**3**
1. Structure	–			–		
2. Curriculum	.72	–		.70	–	
3. Freedom	.38	.35***	–	.60***	.66	–

***$p < .001$.

To facilitate the use of the Teacher Questionnaires of Montessori Practices, we encourage other researchers to contact us about using these instruments in their work and to help us continue to build a dataset for examining their psychometric properties.

AUTHOR INFORMATION

†Corresponding Author
Angela Murray† is the director of the University of Kansas Center for Montessori Research and can be reached at akmurray@ku.edu.

Carolyn Daoust is a research associate at the University of Kansas Center for Montessori Research.

Jie Chen is a Psychometrician and research associate at the University of Kansas Center for Montessori Research.

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Appendix A

Instruments

Early Childhood

Q4 Please indicate how strongly you agree or disagree with each of the following statements about your classroom. In my classroom…

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
A full set of Montessori materials is available.	○	○	○	○
There are at least 3 age levels.	○	○	○	○
Children may choose to skip circle time.	○	○	○	○
Snack is a self-serve activity.	○	○	○	○
Art materials are available all day.	○	○	○	○
Children give lessons to one another.	○	○	○	○
A polishing activity is available.	○	○	○	○
At least 25 children typically attend each day.	○	○	○	○

Q6 Please indicate how strongly you agree or disagree with each of the following statements about your classroom. I make sure that…

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
Observation is used for daily lesson planning.	○	○	○	○
Children's activities are recorded each day.	○	○	○	○
There is a 3-hour uninterrupted work period.	○	○	○	○
Lessons are mostly given to individuals.	○	○	○	○
Breakable materials are available.	○	○	○	○
Classroom books feature realistic stories.	○	○	○	○
Children regularly prepare food.	○	○	○	○
Older children do golden bead addition.	○	○	○	○

Q7 **Please indicate how strongly you agree or disagree with each of the following statements about your classroom. The children in my classroom…**

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
May choose to work alone or with others.	○	○	○	○
Decide where they will work.	○	○	○	○
Care for classroom plants.	○	○	○	○
Care for classroom animals.	○	○	○	○
Choose their work/activities.	○	○	○	○
Determine how long to work with an activity.	○	○	○	○
Are evenly spread across at least a 3-yr age span.	○	○	○	○
Walk on the line carrying objects.	○	○	○	○
Regularly use the Montessori bells.	○	○	○	○
Garden in a designated area.	○	○	○	○

Elementary

Q4 **Please indicate how strongly you agree or disagree with each of the following statements about your classroom. In my classroom…**

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
Children are in at least 3 grade levels.	○	○	○	○
Children decide when to have snack.	○	○	○	○
All children go out for lunchtime recess.	○	○	○	○
Spelling exercises are individualized.	○	○	○	○
Small groups do “going out” excursions.	○	○	○	○
Most lessons last 15 minutes or less.	○	○	○	○
Problem solving with students addresses off-task behavior.	○	○	○	○
1-on-1 meetings are held at least every 2 weeks.	○	○	○	○
Children help make classroom rules/guidelines.	○	○	○	○
Art materials are available all day.	○	○	○	○
Children correct their own work.	○	○	○	○
There is a full set of large geography charts.	○	○	○	○

Q6 **Please indicate how strongly you agree or disagree with each of the following statements about your classroom. I make sure that…**

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
Montessori Great Lessons/Stories are given each fall.	○	○	○	○
Observation is used for daily lesson planning.	○	○	○	○
Children use human fundamental needs charts.	○	○	○	○
Children develop a system for classroom maintenance.	○	○	○	○
Children record activities in work journals.	○	○	○	○
There is a 3-hour uninterrupted work period.	○	○	○	○
Children give lessons to one another.	○	○	○	○
Most lessons are given in groups of 2-5 children.	○	○	○	○
Most instruction is given with Montessori materials.	○	○	○	○
Children regularly prepare food.	○	○	○	○

Q7 **Please indicate how strongly you agree or disagree with each of the following statements about your classroom. The children in my classroom…**

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
Do research based on interests.	○	○	○	○
Choose their work/activities.	○	○	○	○
Decide if they will do a follow-up activity.	○	○	○	○
Determine how long to work with an activity.	○	○	○	○
Decide where they will work.	○	○	○	○
May choose to work alone or with others.	○	○	○	○
Make history timelines.	○	○	○	○
Create their own math problems.	○	○	○	○
Repeat Montessori science experiments.	○	○	○	○
Have access to a full set of Montessori materials.	○	○	○	○
Take part in community service projects.	○	○	○	○

Appendix B
Teacher Questionnaire of Montessori Practices: Early Childhood
References by Item

Montessori Logic Model inputs*	Teacher Questionnaire items	References by source type		
		Organizational standards	Dr. Maria Montessori and associates	Other publications
Mixed age grouping across a 3-year age span	[Children] are evenly spread across at least a 3-yr age span. (Q7.7) There are at least 3 age levels. (Q4.2)	AMI/USA - 2009, p. 13-15 AMS - 2014, p. 7 MAFL - 2012, p. 17, 19, 23, 34, 51, 55, 76 MPPI - 2015, p. 2 NCMPS - 2015, p. 2	Montessori, M. - 1964, p. 373 - 1988, p. 329 - 1989, p. 194, 225-228 - 2008, p. 65	Chattin-McNichols, J. - 1992, p. 166, 168-169 Lillard, A.S. - 2005, p. 20, 144-145, 201-203, 304 Lillard, P.P. - 1972, p. 75 - 1996, p. 34, 39, 41 Pendersen & Pendersen - 2008, p. 23, 38 Rambusch & Stoops - 1992, p. 37
3-hour uninterrupted work periods	There is a three-hour uninterrupted work period. (Q6.3)	AMI/USA - 2009, p. 22-26 AMS - 2014, p. 8-9 MAFL - 2012, p. 17, 18, 34, 52, 53 MPPI - 2015, p. 1 NCMPS - 2015, p. 2	Montessori, M. - 1963, p. 57, 67, 68, 88 - 1965b, p. 50, 81 - 1976, p. 82, 135-136 - 1988, p. 85 - 1989, p. 241, 272, 279 - 1997, p. 32, 35 - 2008, p. 5, 8, 16, 19, 21 Montessori, M.M. - 1976, p. 41 Standing, E.M. - 1984, p. 292	Chattin-McNichols, J. - 1992, p. 16 Daoust, C. - 2004, p. 60-62, 112, 113 Lillard, A.S. - 2005, p. 73-74, 108-110, 300, 304 Lillard, P.P. - 1972, p. 54, 57, 65, 87 - 1980, p. 12 Pendersen & Pendersen - 2008, p. 24
Full set of Montessori materials	A full set of Montessori materials is available. (Q4.1) Art materials are available all day. (Q4.5) A polishing activity is available. (Q4.7) Older children do golden bead addition. (Q6.9) [Children] regularly use the Montessori bells. (Q7.9)	AMI/USA - 2009, p. 10 AMS - 2014, p. 6, 8 MAFL - 2012, p. 22, 51 MPPI - 2015, p. 1 NCMPS - 2015, p. 3	Montessori, M. - 1965a, p. 50-57 etc. - 1970, p. 155-156 - 1988, p. 107 - 1989, p. 223 - 1997, p. 13, 295 - 2008, p. 23, 64	Haines A.M. - 1997, p. 30-31, 84-88, 90 Lillard, A.S. - 2005, p. 18, 21-22, 97, 252 Lillard, P.P. - 1972, p. 58, 70-74 - 1996, p.40 Pendersen & Pendersen - 2008, p. 28
Small group / one-on-one instruction	Lessons are mostly given to individuals. (Q6.4)	AMI/USA - 2009, p. 6, 8, 9 AMS - 2014, p. 9 MAFL - 2012, p. 21, 23, 34 MPPI - 2015, p. 2 NCMPS - 2015, p. 3	Montessori, M. - 1964, p. 107, 108, 113 - 1966, p. 139 - 1970, p. 136, 137 - 1988, p. 108, 152 - 1989, p. 270, 271 - 1997, p. 288, 295 - 2008, p. 17, 23 Montessori, M.M. - 1976, p. 24, 28 Standing, E.M. - 1984, p. 311	Chattin-McNichols, J. - 1992, p. 53, 56-57, 60, 66, 93 Daoust, C. - 2004, p. 114, 115 Joosten, A.M. - 2013, p. 12-13, 15 Lillard, A.S. - 2005, p. 21, 141, 146 Lillard, P.P. - 1972, p. 54, 55, 60, 65 - 1980, p. 11, 15 Pendersen & Pendersen - 2008, p. 24 Rambusch & Stoops - 1992, p. 36
Extensive student choice	[Children] choose their work / activities. (Q7.5) May choose to skip circle time. (Q4.3)	AMI/USA - 2009, p. 25 AMS - 2014, p. 6 MAFL - 2012, p.15, 16, 18, 20, 21, 25 MPPI - 2015, p. 2, 3 NCMPS - 2015, p. 3	Montessori, M. - 1965a, p. 131 - 1965b, p. 71 - 1966, p. 111, 121,139 - 1988, p. 65, 99, 150 - 1989, p. 207, 223 - 1997, p. 13, 30, 61, 291 - 2008, p. 18, 26 Montessori, M.M. - 1976, p. 43	Chattin-McNichols, J. - 1992, p. 44, 54, 66, 160, 168 Lillard, A.S. - 2005, p. 30, 74, 80, 90, 98, 101-102, 326 Lillard, P.P. - 1972, p. 54, 55 - 1980, p. 12 Pendersen & Pendersen - 2008, p. 24 Rambusch & Stoops - 1992, p. 36, 43

Montessori Logic Model inputs*	Teacher Questionnaire items	References by source type		
		Organizational standards	Dr. Maria Montessori and associates	Other publications
Extensive student choice (continued)	[Children] may choose to work alone or with others. (Q7.1)	AMI/USA - 2009, p. 13. 18 AMS - 2014, p. 9 MAFL - 2012, p. 19, 24, 51	Montessori, M. - 1988, p. 86 - 1989, p. 228, 231 - 1997, p. 291 - 2008, p. 22, 24 - 2013, p. 12, 18 Montessori, M.M. - 1976, p. 28-29, 95	Chattin-McNichols, J. - 1992, p. 44, 86 Lillard, A.S. - 2005, p. 21, 29, 30, 32, 74, 193, 209-210 Lillard, P.P. - 1972, p. 55 Pendersen & Pendersen - 2008, p. 25, 38 Rambusch & Stoops - 1992, p. 37, 43
	Snack is a self-serve activity.(4.4)	MAFL - 2012, p. 35		Chattin-McNichols, J. - 1992, p. 16, 50 Daoust, C. - 2004, p. 113, 115 Lillard, A. S. - 2005, p. 48
	[Children] determine how long to work with an activity. (Q7.6)	MAFL - 2012, p. 18, 21, 75 NCMPS - 2015, p. 2, 3	Montessori, M. - 1965b, p. 71 - 1988, p. 98, 163 - 1989, p. 199	Joosten, A.M. - 2013, p. 19 Lillard, A.S. - 2005, p. 80, 91 Rambusch & Stoops - 1992, p. 36, 43
	[Children] decide where they will work. (Q7.2)	MAFL - 2012, p. 18 MPPI - 2015, p. 2 NCMPS - 2015, p. 3	Montessori, M. - 1988, p. 98 - 1997, p. 29 - 2008, p. 67 - 2013, p. 16, 18	Lillard, A.S. - 2005, p. 21 Pendersen & Pendersen - 2008, p. 26 Standing, E.M. - 1984, p. 277
Larger classes / higher child to teacher ratios	At least 25 children typically attend each day. (Q4.8)	AMI/USA - 2009, p. 18-20 AMS - 2014, p. 8 MPPI - 2015, p. 2	Montessori, M. - 1972, p. 92 - 1988, p. 114, 302 - 2008, p. 45, 64-65 - 2013, p. 14 Standing, E.M. - 1984, p. 277-278	Lillard, A.S. - 2005, p. 202 Lillard, P.P. - 1996, p. 34, 40 Pendersen & Pendersen - 2008, p. 23
Montessori classroom design and pedagogy	Breakable materials are available. (Q6.5)	MAFL - 2012, p. 35 NCMPS - 2015, p. 3	Montessori, M. - 1965a, p. 43 - 1965b, p. 121, 250 - 1970, p. 97-98 - 1997, p. 200-202, 330-332	Chattin-McNichols, J. - 1992, p. 74, 75, 76, 83 Lillard, P.P. - 1972, p. 58, 59 Pendersen & Pendersen - 2008, p. 29
	[Children] garden in a designated area. (Q7.10)	MAFL - 2012, p. 50, 66 NCMPS - 2015, p. 3	Montessori, M. - 1964, p. 157-159 - 1965a, p. 60 - 1988, p. 84 - 2013, p. 14, 17-18	Lillard, P.P. - 1972, p. 59
	Classroom books feature realistic stories. (Q6.6)	MAFL - 2012, p. 56, 57		Lillard, A.S. - 2005, p. 185
	Children regularly prepare food. (Q6.7)	MAFL - 2012, p. 49, 55, 64, NCMPS - 2015, p. 3		Chattin-McNichols, J. - 1992, p. 50, 53, 73, 75 Lillard, A.S. - 2005, p. 48 Lillard, P.P. - 1972, p. 58
	Children give lessons to one another. (Q4.6)	AMI/USA - 2009, p. 2, 13, 14, 18 MAFL - 2012, p. 19, 51	Montessori, M. - 1989, p. 228 - 2008, p. 68-69 Standing, E.M. - 1984, p. 278	Lillard, A.S. - 2005, p. 209 Lillard, P.P. - 1972, p. 76 Pendersen & Pendersen - 2008, p. 25, 38
	[Children] walk on the line carrying objects. (Q7.8)	MAFL - 2012, p. 50, 78	Montessori, M. - 1965a, p. 63-64 - 1988, p. 92 Standing, E.M. - 1984, p. 224-225	Lillard, P.P. - 1972, p. 127

Montessori Logic Model inputs*	Teacher Questionnaire items	References by source type		
		Organizational standards	Dr. Maria Montessori and associates	Other publications
Montessori classroom design and pedagogy (continued)	[Children] care for classroom plants. (Q7.3)	MAFL - 2012, p. 34, 50, 65, 66, 67	Montessori, M. - 1964, p. 157-158 - 1965b, p. 161 - 1988, p. 73-77, 84 - 2013, p. 17 Montessori, M.M. - 1964, p. 29	Joosten, A.M. - 2013, p. 23, 27, 28, Lillard, A.S. - 2005, p. 48, 310 Lillard, P.P. - 1972, p. 58-59, 74 Pendersen & Pendersen - 2008, p. 25, 26, 35
	[Children] care for classroom animals. (Q7.4)			
Teacher observation, ongoing assessment	Children's activities are recorded each day. (Q6.2)	AMS - 2014, p. 9 MAFL - 2012, p. 21, 23-25 MPPI - 2015, p. 2 NCMPS - 2015, p. 8	Montessori, M. - 2013, p. 19 Montessori, M.M. - 1976, p. 44	Joosten, A.M. - 2013, p. 19 Lillard, A.S. - 2005, p. 142 Pendersen & Pendersen - 2008, p. 23, 31
	Observation is used for daily lesson planning. (Q6.1)	AMS - 2014, p. 4, 9 MAFL - 2012, p. 21, 23, 24, 32 NCMPS - 2015, p. 8	Montessori, M. - 1964, p. 108 - 1970, p. 139 - 1988, p. 109, 151 - 1997, p. 138, 288 - 2013, p. 19 Standing, E.M. - 1984, p. 293, 310	Lillard, A.S. - 2005, p. 141-142, 282 Lillard, P.P. - 1972, p. 60, 79-82 Pendersen & Pendersen - 2008, p. 23, 31

*Aligned with inputs from the Logic Model for Montessori Education (Culclasure, Daoust, Morris Cote, & Zoll, 2019).
Note. Logic Model inputs of Credentialed Teachers, Continuing Professional Development, and Diverse Population of Students were not asked as Likert items in the Teacher Questionnaire. They were asked as direct questions about teacher and classroom characteristics in another section and will be included in future analysis.

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Appendix C
Teacher Questionnaire of Montessori Practices: Elementary
References by Item

Montessori Logic Model inputs*	Teacher Questionnaire items	References by source type		
		Organizational standards	Dr. Maria Montessori and associates	Other publications
Mixed age grouping across a 3-year age span	Children are in at least 3 grade levels. (Q4.1)	AMI/USA - 2009, p. 13-15 AMS - 2014, p. 7 MAFL - 2012, p. 17, 19, 23, 240 MPPI - 2015, p. 2 NCMPS - 2015, p. 2	Montessori, M. - 1964, p. 373 - 1988, p. 329 - 1989, p. 194, 225-228 - 2008, p. 65, 68-69,	Chattin-McNichols, J. - 1992, p. 166, 168-169, 209 Grazzini, B.K. - 2010, p. 84 Lillard, A.S. - 2005, p. 20, 201-203, 304 Lillard, P.P. - 1996, p. 78, 87 Pendersen & Pendersen - 2008, p. 23, 38 Rambusch & Stoops - 1992, p. 37
3-hour uninterrupted work periods	There is a 3-hour uninterrupted work period. (Q6.6)	AMI/USA - 2009, p. 22-26 AMS - 2014, p. 8-9 MAFL - 2012, p. 17, 18, 88, 209, 211 MPPI - 2015, p. 1 NCMPS - 2015, p. 2	Montessori, M. - 1965, p. 50, 81 - 1976, p. 82, 135-136 - 1988, p. 85 - 1989, p. 241, 272 - 1997, p. 13, 34, 35 - 2008, p. 5, 8, 32 Montessori, M.M. - 1976, p. 41 Standing E.M. - 1984, p. 292	Chattin-McNichols, J. - 1992, p. 16 Grazzini, B.K. - 2010, p. 84 Lillard, A.S. - 2005, p. 73-74, 108-110, 300, 304 Lillard, P.P. - 1996, p. 93-94 Pendersen & Pendersen - 2008, p. 24
Full set of Montessori materials	[Children] have access to a full set of Montessori materials. (7.10) Art materials are available all day. (Q4.10) Most instruction is given with Montessori materials. (Q6.9)	AMI/USA - 2009, p. 10 AMS - 2014, p. 6, 8 MAFL - 2012, p. 22, 209-214 MPPI - 2015, p. 1 NCMPS - 2015, p. 3	Montessori, M. - 1970, p. 155-156 - 1988, p. 107 - 1997, p. 12, 29, 33 - 1997b, p. 13, 295 - 2008, p. 64 Montessori, M.M. - 1976, p. 21, 24, 69	Chattin-McNichols, J. - 1992, p. 54, Lillard, A. S. - 2005, p. 18, 21-22, 252 Pendersen & Pendersen - 2008, p. 27(art), 28 Lillard, P.P. - 1996, p. 78
	There is a full set of large geography charts. (Q4.12)	MAFL - 2012, p. 96, 183, 189, 190, 191, 203-205, 208	Montessori, M. - 1976, p. 39-40, 63-64, 77, 79	Chattin-McNichols, J. - 1992, p. 81, 132, 143-144 Daoust & Suzuki - 2014, research poster Lillard, A.S. - 2005, p. 132
	[Children] repeat Montessori science experiments. (Q7.9)	MAFL - 2012, p. 178, 179, 183, 189, 192, 203		Chattin-McNichols, J. - 1992, p. 144
	Children use human fundamental needs charts. (Q6.3)	MAFL - 2012, p. 176, 180, 185, 186, 196-198, 234, 235		Chattin-McNichols, J. - 1992, p. 142-143, 146, 149 Daoust & Suzuki - 2013, research poster Lillard, A.S. - 2005, p. 71 Lillard, P.P. - 1996, p. 73-74

Montessori Logic Model inputs*	Teacher Questionnaire items	References by source type		
		Organizational standards	Dr. Maria Montessori and associates	Other publications
Small group / one-on-one instruction	Most lessons are given in groups of 2-5 children. (Q6.8)	AMI/USA - 2009, p. 6, 8, 9 AMS - 2014, p. 9 MAFL - 2012, p. 21, 23, 86, 87 MPPI - 2015, p. 2 NCMPS - 2015, p. 3 MAFL - 2012, p. 87, 89, 160, 236,	Montessori, M. - 1970, p. 136, 137 - 1997b, p. 288, 295, Standing E.M. - 1984, p. 311	Chattin-McNichols, J. - 1992, p. 57 Lillard, A.S. - 2005, p. 21 Pottish-Lewis, P. - 2011, p. 12
	Most lessons last 15 minutes or less. (Q4.6)		Montessori, M. - 1964, p. 107, 108 Montessori, M.M. - 1976, p. 24, 28 - 1997, p. 35	Chattin-McNichols, J. - 1992, p. 55-57, 60, 66 Lillard, A.S. - 2005, p. 21, 141, 203 Pendersen & Pendersen - 2008, p. 24, 34 Pottish-Lewis, P. - 2011, p. 5, 6, 12, 14 Rambusch & Stoops - 1992, p. 36
Extensive student choice	[Children] choose their work / activities. (Q7.2)	AMI/USA - 2009, p. 25 AMS - 2014, p. 6 MAFL - 2012, p. 15, 16, 18, 20, 21, 25, 236, MPPI - 2015, p. 1 NCMPS - 2015, p. 3	Montessori, M. - 1965, p. 71 - 1976, p. 29 - 1988, p. 65, 99, 150 - 1989, p. 207, 223 - 1997, p. 27 - 1997b, p. 13, 30, 61, 291 - 2008, p. 40-41 - 1973, p. 7 Montessori, M.M. - 1976, p. 43, 63 Standing E.M. - 1984, p. 364, 365	Chattin-McNichols, J. - 1992, p. 44, 54, 66,160, 168, 134-135 Daoust & Suzuki - 2014, research poster Lillard, A.S. - 2005, p. 30, 74, 80, 90, 98, 101-102, 304, 326 Lillard, P.P. - 1996, p. 91 MacDonald, G. - 2016, p. 146, 150 Pendersen & Pendersen - 2008, p. 24 Pottish-Lewis, P. - 2011, p. 3-5 Rambusch & Stoops - 1992, p. 36, 43
	[Children] decide if they will do a follow-up activity. (Q7.3)	MAFL - 2012, p. 88, 179		Chattin-McNichols, J. - 1992, p. 124 Lillard, P.P. - 1996, p. 91
	Children decide when to have snack. (Q4.2)			Chattin-McNichols, J. - 1992, p. 16, 50 Daoust & Suzuki - 2014, research poster
	[Children] may choose to work alone or with others. (Q7.6)	AMI/USA - 2009, p. 13, 18 AMS - 2014, p. 9 MAFL - 2012, p. 18, 19, 24, 86, 87, 88, 99, 180	Montessori, M. - 1976, p. 26 - 1989, p. 235 - 1997b, p. 291 - 2008, p. 40 Montessori, M.M. - 1976, p. 28-29, 95 Standing E.M. - 1984, p. 356-367	Chattin-McNichols, J. - 1992, p. 44 Grazzini, B.K. - 2010, p. 87 Lillard, A.S. - 2005, p. 21, 29, 30, 32, 74, 91, 180, 193, 209-210, 217-218, 327 Lillard, P.P. - 1996, p. 70, 93 Pendersen & Pendersen - 2008, p. 25, 38 Pottish-Lewis, P. - 2011, p. 6-7, 16 Rambusch & Stoops - 1992, p. 37, 43
	[Children] decide where they will work. (Q7.5)	MAFL - 2012, p. 18, 234 MPPI - 2015, p. 2 NCMPS - 2015, p. 3	Montessori, M. - 1988, p. 98 - 1997b, p. 291 - 2008, p. 67-68 Standing E.M. - 1984, p. 277	Daoust & Suzuki - 2014, research poster Lillard, A.S. - 2005, p. 21 MacDonald, G. - 2016, p. 150 Pendersen & Pendersen - 2008, p. 26

Montessori Logic Model inputs*	Teacher Questionnaire items	References by source type		
		Organizational standards	Dr. Maria Montessori and associates	Other publications
Extensive student choice (continued)	[Children] determine how long to work with an activity. (Q7.4)	MAFL - 2012, p. 18, 21, 88, 236 NCMPS - 2015, p. 2, 3	Montessori, M. - 1965, p. 71, 90 - 1988, p. 98 - 1989, p. 199 - 1997, p. 28 - 2008, p. 40-41	Lillard, A.S. - 2005, p. 80, 91, 99, 102 MacDonald, G. - 2016, p. 150 Pottish-Lewis, P. - 2011, p. 16, 22 Rambusch & Stoops - 1992, p. 36, 43
	[Children] do research based on interests. (Q7.1)	AMS - 2014, p. 5 MAFL - 2012, p. 17, 18, 90, 179-180, 210	Montessori, M. - 1976, p. 36, 38 - 1973, p. 25 - 1997, p. 26, 29, 33-34 - 2008, p. 40 Standing E.M. - 1984, p. 365-366	Lillard, A.S. - 2005, p. 71, 115, 122, 128 Lillard, P.P. - 1996, p. 23, 91 MacDonald, G. - 2016, p. 146 Pendersen & Pendersen - 2008, p. 24 Pottish-Lewis, P. - 2011, p. 5, 16, 17
	Children help make classroom rules / guidelines. (Q4.9)	MAFL - 2012, p. 99, 235, 237, 240		
	Small groups do “going out” excursions. (Q4.5)	AMS - 2014, p. 5 MAFL - 2012, p. 89, 99, 100, 118, 183, 185, 186, 187, 191-193, 196-200, 202-208, 210	Montessori, M. - 1972, p. 81 - 1976, p. 25, 26, 28, 33, 34, 35 Standing E.M. - 1984, p. 353-355	Lillard, A.S. - 2005, p. 72-73, 91, 122, 132, 225, 253 Lillard, P.P. - 1996, p. 58, 102-111 Pendersen & Pendersen - 2008, p. 27
	Children develop a system for classroom maintenance. (Q6.4)	MAFL - 2012, p. 234		Chattin-McNichols, J. - 1992, p. 80 Lillard, P.P. - 1996, p. 101, 102 Pottish-Lewis, P. - 2011, p. 21, 22
Montessori classroom design and pedagogy	Montessori Great Lessons / Stories are given each fall. (Q6.1)	MAFL - 2012, p. 87-88, 91, 176, 179, 183, 184, 189, 195-197,	Montessori, M. - 1973, p. 8-10, 16 - 1976, p. 37, 49 - 2008, p. 47, 49	Chattin-McNichols, J. - 1992, p. 143-145 Daoust & Suzuki - 2014, research poster Grazzini, B.K. - 2010, p. 88-92 Lillard, A.S. - 2005, p. 129-135 Lillard, P.P. - 1996, p. 54-76 Pottish-Lewis, P. - 2011, p. 22
	[Children] make history timelines. (Q.7.7)	MAFL - 2012, p. 181, 183, 184, 185, 186		Chattin-McNichols, J. - 1992, p. 145 Lillard, A.S. - 2005, p. 133 Lillard, P.P. - 1996, p. 72
	All children go out for recess. (Q4.3)	MAFL - 2012, p. 87, 89, 235	Montessori, M. - 1965, p. 261 - 1988, p. 17-19, 61-62 - 1989, p. 194, 244-24 - 1997, p. 43-44 - 1997b, p. 277, 286, 329 - 2008, p. 28-30 Standing E.M. - 1984, p. 310	Chattin-McNichols, J. - 1992, p. 64, 89-90 Kahn, D. - 1995, p. 11 Lillard, A.S. - 2005, p. 182 Lillard, P.P. - 1972, p. 55 MacDonald, G. - 2016, p. 148-149
	Problem-solving with students addresses off-task behavior. (Q4.7)			

Montessori Logic Model inputs*	Teacher Questionnaire items	References by source type		
		Organizational standards	Dr. Maria Montessori and associates	Other publications
Montessori classroom design and pedagogy (continued)	1-on-1 meetings are held at least every 2 weeks. (Q4.8)	NCMPS - 2015, p. 9 MAFL - 2012, p. 24, 87		Chattin-McNichols, J. - 1992, p. 135 Lillard, A.S. - 2005, p. 149-150 Lillard, P.P. - 1996, p. 100 MacDonald, G. - 2016, p. 142 Pottish-Lewis, P. - 2011, p. 19
	Children record activities in work journals. (Q6.5)	NCMPS - 2015, p. 9 MAFL - 2012, p. 87		Lillard, P.P. - 1996, p. 97, 99, 101-102, 149,180 Lillard, A.S. - 2005, p. 149 Pendersen & Pendersen - 2008, p. 36 Pottish-Lewis, P. - 2011, p. 17-19
	[Children] create their own math problems. (Q7.8)			MacDonald, G. - 2016, p. 146
	Spelling exercises are individualized. (Q4.4)	MAFL - 2012, p. 20	Montessori, M. - 2008, p. 87-88	Pottish-Lewis, P. - 2011, p. 13-14 Rambusch & Stoops - 1992, p. 37
	Children correct their own work. (Q4.11)	MAFL - 2012, p.		Chattin-McNichols, J. - 1992, p. 55 Lillard, A.S. - 2005, p. 176-180
	Children give lessons to one another. (Q6.7)	AMI/USA - 2009, p. 2, 13, 14, 18 MAFL - 2012, p. 19, 51,	Standing E.M. - 1984, p. 278	Kahn, D. - 1995, p. 13 Lillard, A.S. - 2005, p. 180-181, 209 Lillard, P.P. - 1972, p. 76
	Children regularly prepare food. (Q6.10)	MAFL - 2012, p. 235, 237 NCMPS - 2015, p. 3		Chattin-McNichols, J. - 1992, p. 50, 53, 73, 75, 79 Lillard, P.P. - 1972, p. 58
	[Children] take part in community service projects. (Q7.11)	MAFL - 2012, p. 235, 237, 240		Kahn, D. - 1995, p. 8 Lillard, P.P. - 1996, p. 111-112 Pendersen & Pendersen - 2008, p. 39
Teacher observation, ongoing assessment	Observation is used for daily lesson planning. (Q6.2)	AMS - 2014, p. 4, 9 MAFL - 2012, p. 21, 23, 24 NCMPS - 2015, p. 8	Montessori, M. - 1964, p. 108 - 1970, p. 139 - 1997b, p. 138, 148-149, 151, 288 Standing E.M. - 1984, p. 293, 310	Kahn, D. - 1995, p. 7 Lillard, A.S. - 2005, p. 141-142, 282 Lillard, P.P. - 1996, p. 72, 91-92 MacDonald, G. - 2016, p. 133, 140-141,159 Pendersen & Pendersen - 2008, p. 23, 31 Pottish-Lewis, P. - 2011, p. 12

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Note. Logic Model inputs of Credentialed Teachers, Larger Class Sizes, Continuing Professional Development, and Diverse Population of Students were not asked as Likert items in the Teacher Questionnaire. They were asked as direct questions about teacher and classroom characteristics in another section and will be included in future analysis.

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Developing Instruments to Measure Montessori Instructional Practices

Technical Appendix (TA)

Angela K. Murray, Carolyn J. Daoust, and Jie Chen

Analysis

Pearson Correlation Analysis

We examined the item-total correlations for current data gathered in 2018 as well as data gathered data from a pilot version of the questionnaire in 2017. We discovered that results were much improved after eliminating problematic items and revising the original pilot instrument. Table TA1 shows the maximum, minimum, and median item-total correlation for each hypothesized construct based on the 2017 pilot and the current data set. Conducting confirmatory factor analysis (CFA) was the next step in the analysis.

Table TA1
Item-Total Correlations from 2017 and 2018 Pilot Data Sets

Data	Construct	Min		Max		Median	
		2017	2018	2017	2018	2017	2018
EC	Structure	0.18	0.44	0.64	0.65	0.41	0.49
	Curriculum	0.31	0.37	0.60	0.64	0.49	0.56
	Freedom	0.21	0.50	0.58	0.61	0.38	0.55
	All	0.10	0.28	0.56	0.64	0.33	0.49
EL	Structure	0.48	0.32	0.61	0.68	0.51	0.49
	Curriculum	−0.23	0.30	0.62	0.69	0.50	0.59
	Freedom	−0.25	0.50	0.66	0.60	0.52	0.58
	All	−0.32	0.23	0.62	0.64	0.44	0.51

CFA

Neither the EC nor EL data set is normally distributed because the majority of the participants agreed on most items and selected response option 3 or 4, making most of the individual items left skewed. Furthermore, the null hypothesis that the variables come from a multivariate normal distribution was rejected with $p < .001$ for Henze-Zirkler (HZ) test (Henze & Zirkler, 1990). However, the use of maximum likelihood with robust estimation method (MLR) corrected the nonnormality. Rhemtulla, Brosseau-Liard, and Savalei (2012) concluded that, although robust categorical methodology (i.e., categorical least squares, or cat-LS, methodology) is best when observed variables have fewer than five categories, factor correlations and model fit were assessed equally well with ML as with cat-LS when categories are fewer than five. Further, we used robust full information maximum likelihood (RFIML) to treat missing ordinal data as if they were continuous (Jia & Wu, 2019). RFIML is superior to the weighted least squares (WLS) method in handling missing data because missing data need to be imputed when WLS is used (Asparouhov & Muthén, 2010). However, data for these analyses showed very few missing responses. Finally, we chose to set the variance of items to 1 and freely estimate all items (Brown, 2006).

Results

Descriptives

Item univariate skewness and kurtosis analysis results are available in Tables TA2-1 through TA2-3 for EC and Tables TA3-1 to TA3-3 for EL.

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Table TA2-1
Early Childhood Univariate Skewness and Kurtosis: Structure

	Q4_02	Q4_06	Q4_08	Q6_01	Q6_02	Q6_03	Q6_04	Q7_07
N valid	241	242	242	240	241	240	241	241
N missing	1	0	0	2	1	2	1	1
Skewness	−2.41	−1.32	−0.02	−1.53	−1.25	−0.78	−0.99	−0.91
SE of skewness	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Kurtosis	4.39	1.40	−1.69	2.23	0.88	−0.30	0.32	−0.39
SE of kurtosis	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

Table TA2-2
Early Childhood Univariate Skewness and Kurtosis: Curriculum

	Q4_01	Q4_05	Q4_07	Q6_05	Q6_06	Q6_07	Q6_08	Q7_03	Q7_04	Q7_08	Q7_09	Q7_10
N valid	241	242	241	239	241	241	240	241	238	240	239	240
N missing	1	0	1	3	1	1	2	1	4	2	3	2
Skewness	−2.23	−2.30	−1.56	−3.44	−1.25	−0.79	−1.66	−1.92	−0.66	−0.99	0.37	−0.86
SE of skewness	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Kurtosis	4.64	5.09	1.31	12.49	1.32	−0.57	1.72	3.24	−1.15	−0.22	−1.37	−0.63
SE of kurtosis	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

Table TA2-3
Early Childhood Univariate Skewness and Kurtosis: Freedom

	Q4_03	Q4_04	Q7_01	Q7_02	Q7_05	Q7_06
N valid	241	241	24	238	240	240
N missing	1	1	2	4	2	2
Skewness	−0.40	−2.22	−1.60	−1.71	−1.56	−2.03
SE of skewness	0.16	0.16	0.16	0.16	0.16	0.16
Kurtosis	−0.84	3.76	1.65	2.10	1.52	4.89
SE of kurtosis	0.31	0.31	0.31	0.31	0.31	0.31

Table TA3-1
Elementary Univariate Skewness and Kurtosis: Structure

	Q4_01	Q4_03	Q4_06	Q4_07	Q4_08	Q6_02	Q6_05	Q6_06	Q6_07	Q6_08
N valid	170	169	170	169	170	169	169	169	169	169
N missing	0	1	0	1	0	1	1	1	1	1
Skewness	−2.88	−2.45	−0.81	−1.34	−0.67	−0.96	−1.79	−1.63	−0.71	−1.07
SE of skewness	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Kurtosis	7.03	5.51	0.33	1.68	−0.63	0.88	2.20	2.11	0.39	0.76
SE of kurtosis	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37

Table TA3-2
Elementary Univariate Skewness and Kurtosis: Curriculum

	Q4_04	Q4_10	Q4_11	Q4_12	Q6_01	Q6_03	Q6_09	Q6_10	Q7_07	Q7_08	Q7_09	Q7_10	Q7_11
N valid	168	170	169	170	169	168	168	169	168	168	168	168	168
N missing	2	0	1	0	1	2	2	1	2	2	2	2	2
Skewness	−1.26	−1.32	−0.55	−1.17	−1.60	−0.94	−1.87	–0.39	−0.68	−0.25	−0.60	−2.34	−0.80
SE of skewness	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Kurtosis	1.43	0.81	0.26	0.09	1.77	0.12	3.62	–1.21	−0.32	−0.65	−0.60	6.38	0.12
SE of kurtosis	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37

Table TA3-3
Elementary Univariate Skewness and Kurtosis: Freedom

	Q4_02	Q4_05	Q4_09	Q6_04	Q7_01	Q7_02	Q7_03	Q7_04	Q7_05	Q7_06
N valid	170	167	170	169	168	167	168	167	168	168
N missing	0	3	0	1	2	3	2	3	2	2
Skewness	−1.73	−0.23	−2.43	−1.15	−1.19	−0.91	−0.46	−1.16	−1.70	−2.51
SE of skewness	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Kurtosis	1.78	−1.45	6.12	1.30	1.40	0.89	−0.24	1.64	3.13	7.42
SE of kurtosis	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37

Initial CFA

Factor loadings for the initial CFA models that incorporated all items from the study are reported in Table TA4 for EC and TA5 for EL.

Table TA4

EC Item Loadings on Each Factor in the Initial CFA Model

Variables	Unstandardized loadings	Std. err	Z-value	Sig	Standardized loadings
Factor 1. Structure					
Q4_02	0.28	0.12	2.31	.02	0.33
Q4_06	0.28	0.10	2.93	<.001	0.35
Q4_08	0.24	0.11	2.22	.03	0.19
Q6_01	0.28	0.09	3.24	<.001	0.37
Q6_02	0.27	0.09	3.10	<.001	0.31
Q6_03	0.34	0.12	2.79	.01	0.37
Q6_04	0.29	0.09	3.09	<.001	0.36
Q7_07	0.30	0.10	2.85	<.001	0.30
Factor 2. Curriculum					
Q4_01	0.44	0.08	5.82	<.001	0.64
Q4_05	0.32	0.09	3.76	<.001	0.50
Q4_07	0.60	0.10	6.15	<.001	0.65
Q6_05	0.33	0.10	3.30	<.001	0.66
Q6_06	0.32	0.09	3.70	<.001	0.45
Q6_07	0.77	0.19	4.12	<.001	0.76
Q6_08	0.38	0.10	3.92	<.001	0.42
Q7_03	0.40	0.12	3.37	<.001	0.52
Q7_04	0.62	0.20	3.08	<.001	0.52
Q7_08	0.67	0.23	2.91	<.001	0.66
Q7_09	0.57	0.17	3.32	<.001	0.49
Q7_10	0.42	0.16	2.58	<.001	0.39
Factor 3. Freedom					
Q4_03	0.67	0.20	3.30	<.001	0.68
Q4_04	0.62	0.18	3.51	<.001	0.75
Q7_01	0.23	0.08	2.67	<.001	0.42
Q7_02	0.29	0.11	2.54	<.001	0.57
Q7_05	0.24	0.07	3.49	<.001	0.49
Q7_06	0.16	0.08	2.07	.04	0.27

Table TA5

EL Item Loadings on Each Factor in the Initial CFA Model

Variables	Unstandardized loadings	Std. err	Z-value	Sig	Standardized loadings
Factor 1. Structure					
Q4_01	0.23	0.13	1.75	.08	0.30
Q4_03	0.18	0.12	1.43	.15	0.24
Q4_06	0.29	0.09	3.13	.00	0.35
Q4_07	0.27	0.10	2.75	.01	0.39
Q4_08	0.63	0.10	6.64	.00	0.65
Q6_02	0.49	0.05	9.02	<.001	0.74
Q6_05	0.45	0.12	3.90	<.001	0.53
Q6_06	0.51	0.09	5.50	<.001	0.63
Q6_07	0.43	0.07	6.04	<.001	0.64
Q6_08	0.44	0.10	4.30	<.001	0.57
Factor 2. Curriculum					
Q4_04	0.47	0.11	4.45	<.001	0.58
Q4_10	0.41	0.11	3.86	<.001	0.47
Q4_11	0.42	0.09	4.60	<.001	0.59
Q4_12	0.22	0.09	2.46	.01	0.22
Q6_01	0.43	0.10	4.25	<.001	0.52
Q6_03	0.53	0.07	7.91	<.001	0.59
Q6_09	0.38	0.11	3.46	<.001	0.59
Q7_07	0.56	0.07	8.58	<.001	0.63
Q7_08	0.61	0.12	5.23	<.001	0.70
Q7_09	0.56	0.07	7.53	<.001	0.64
Q7_10	0.31	0.09	3.54	<.001	0.53
Q7_11	0.45	0.10	4.69	<.001	0.55
Factor 3. Freedom					
Q4_02	0.51	0.11	4.84	<.001	0.57
Q4_05	0.77	0.08	9.56	<.001	0.66
Q4_09	0.38	0.08	4.73	<.001	0.57
Q6_04	0.51	0.07	6.81	<.001	0.70
Q6_10	0.37	0.07	5.66	<.001	0.63
Q7_01	0.36	0.07	5.27	<.001	0.62
Q7_02	0.39	0.09	4.55	<.001	0.48
Q7_03	0.26	0.08	3.35	<.001	0.42
Q7_04	0.28	0.08	3.44	<.001	0.46
Q7_05	0.26	0.08	3.13	<.001	0.48
Q7_06	0.51	0.11	4.84	<.001	0.57

IRT Analysis

Model fit for the IRT analysis after removing problematic items is provided in Table TA6 for EC and TA7 for EL. Item characteristic curves (ICC) for each construct are provided in Figures TA1 through TA6.

Table TA6

EC IRT Model Fit

	Marginal reliability	2loglikelihood	AIC	BIC	Number of freely estimated parameters
Structure	0.63	3,480.77	3,528.77	3,612.51	24
Curriculum	0.76	4,632.73	4,704.73	4,830.33	36
Freedom	0.62	1,951.24	1,987.24	2,050.04	18

Table TA7

EL IRT Model Fit

	Marginal reliability	2loglikelihood	AIC	BIC	Number of freely estimated parameters
Structure	0.66	2,075.65	2,117.65	2,183.50	21
Curriculum	0.79	2,629.01	2,683.01	2,767.67	27
Freedom	0.66	1,451.39	1,487.39	1,543.83	18

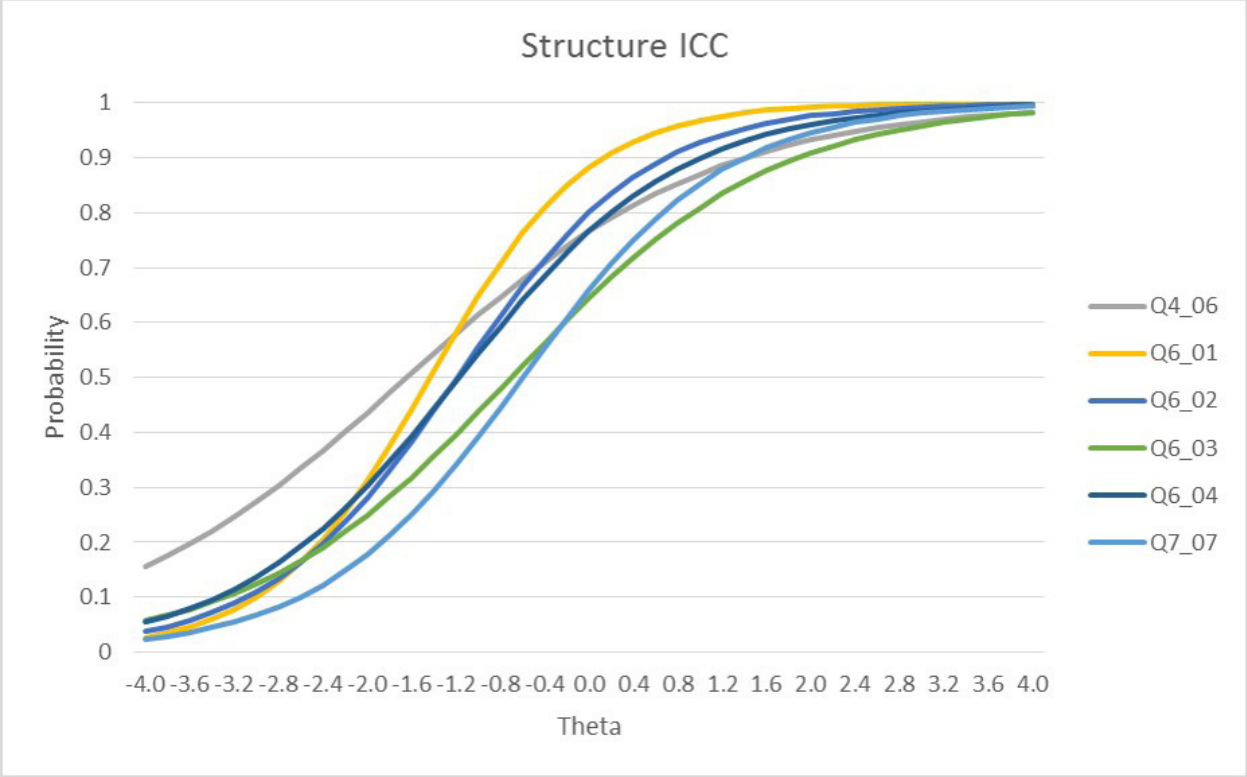

Figure 1. Item characteristics curve: EC items in structure construct.

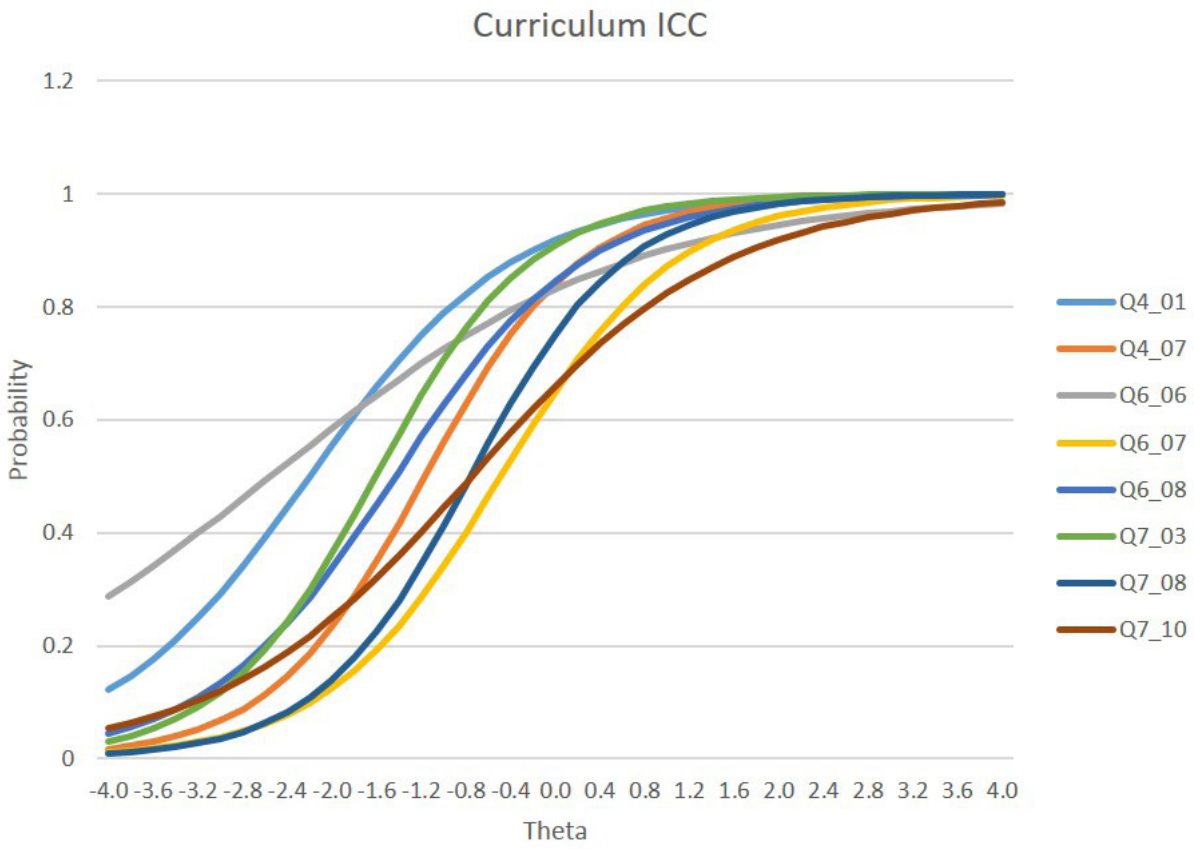

Figure 2. Item characteristics curve: EC items in curriculum construct.

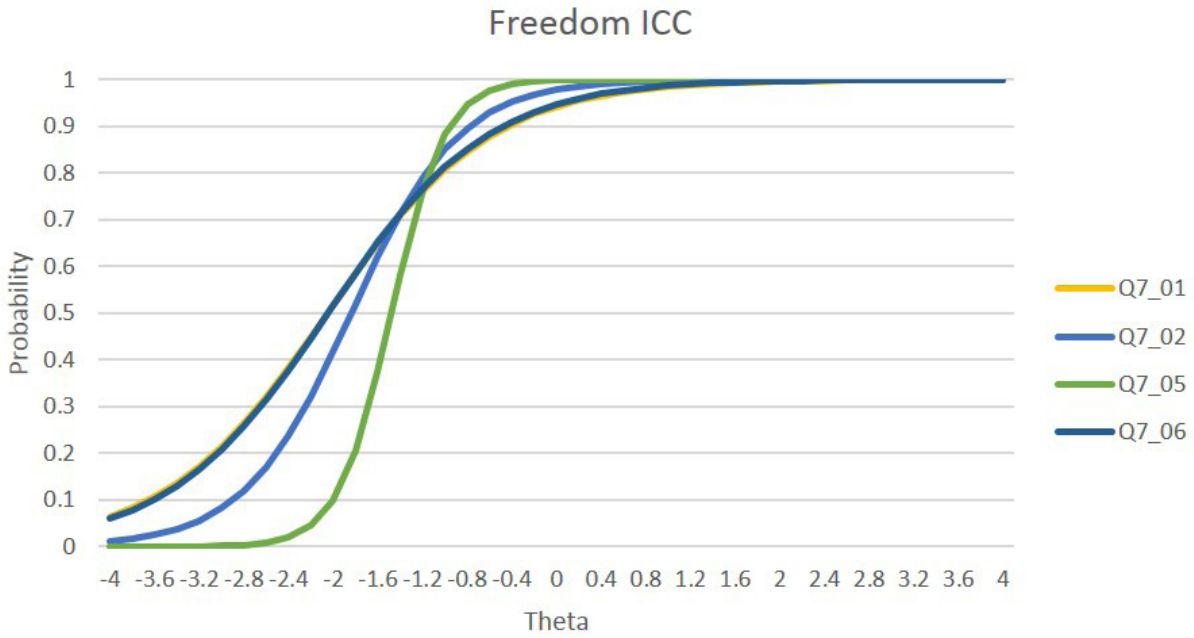

Figure 3. Item characteristics curve: EC items in freedom construct.

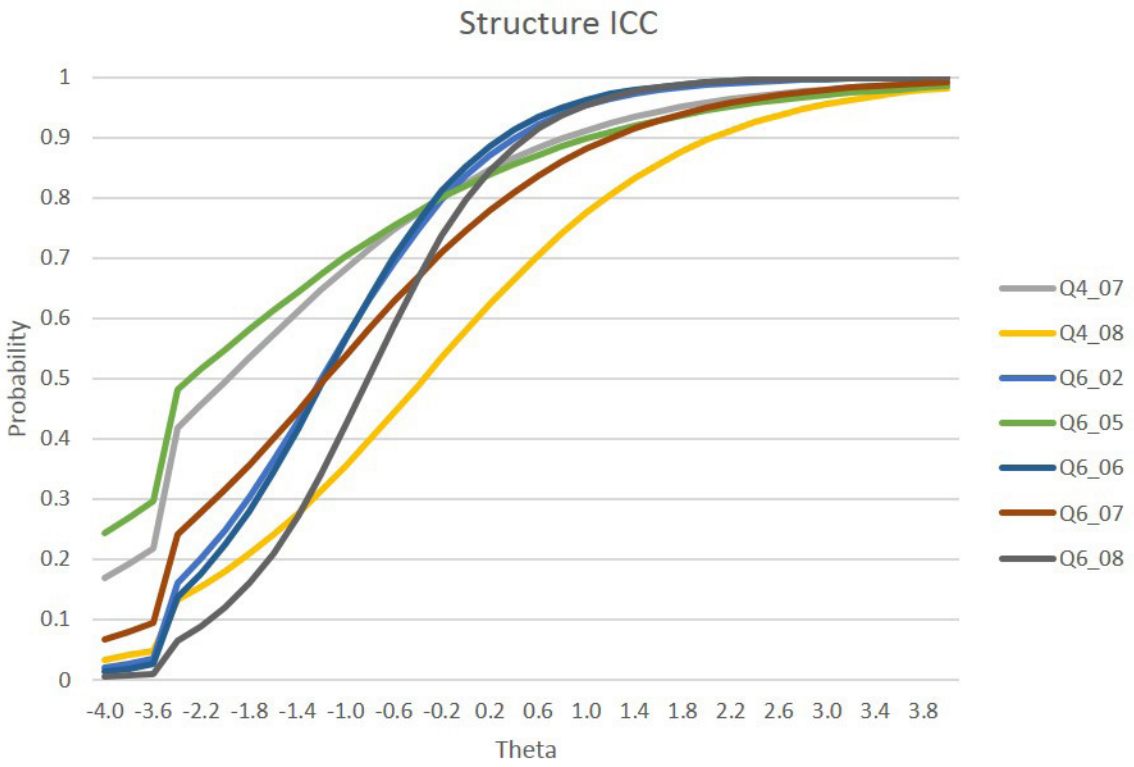

Figure 4. Item characteristics curve: EL items in structure construct.

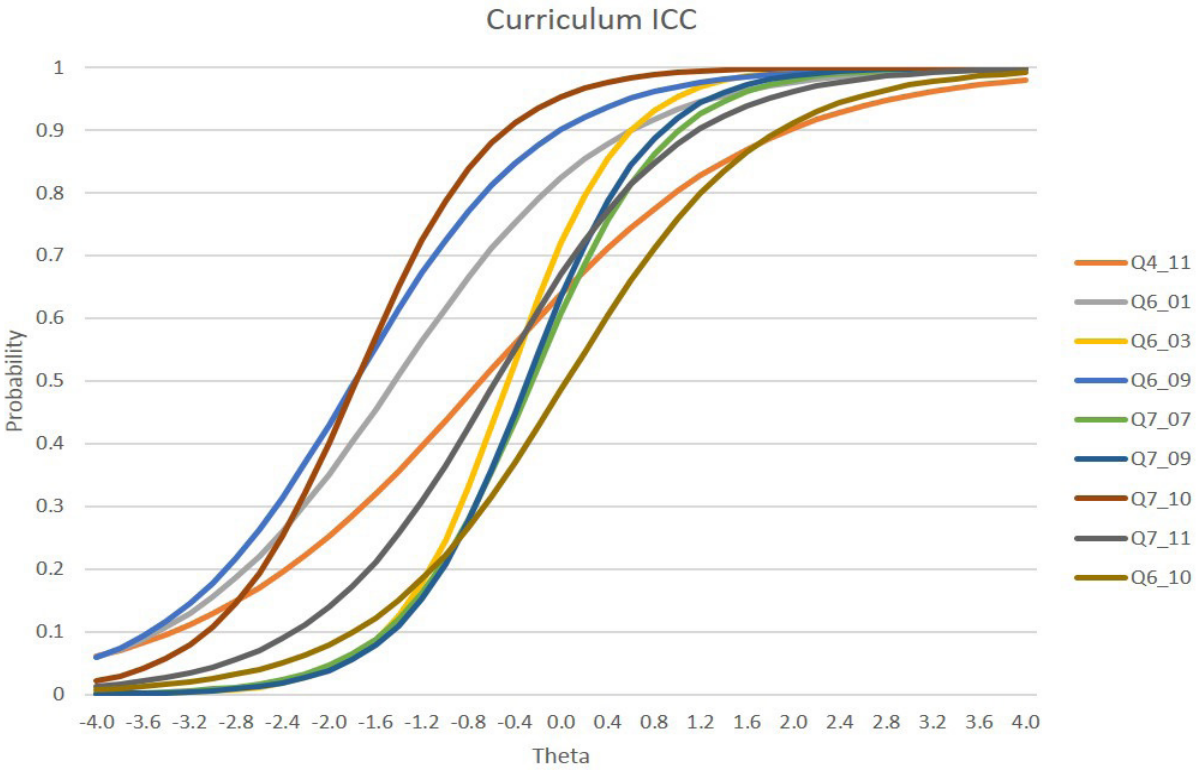

Figure 5. Item characteristics curve: EL items in curriculum construct.

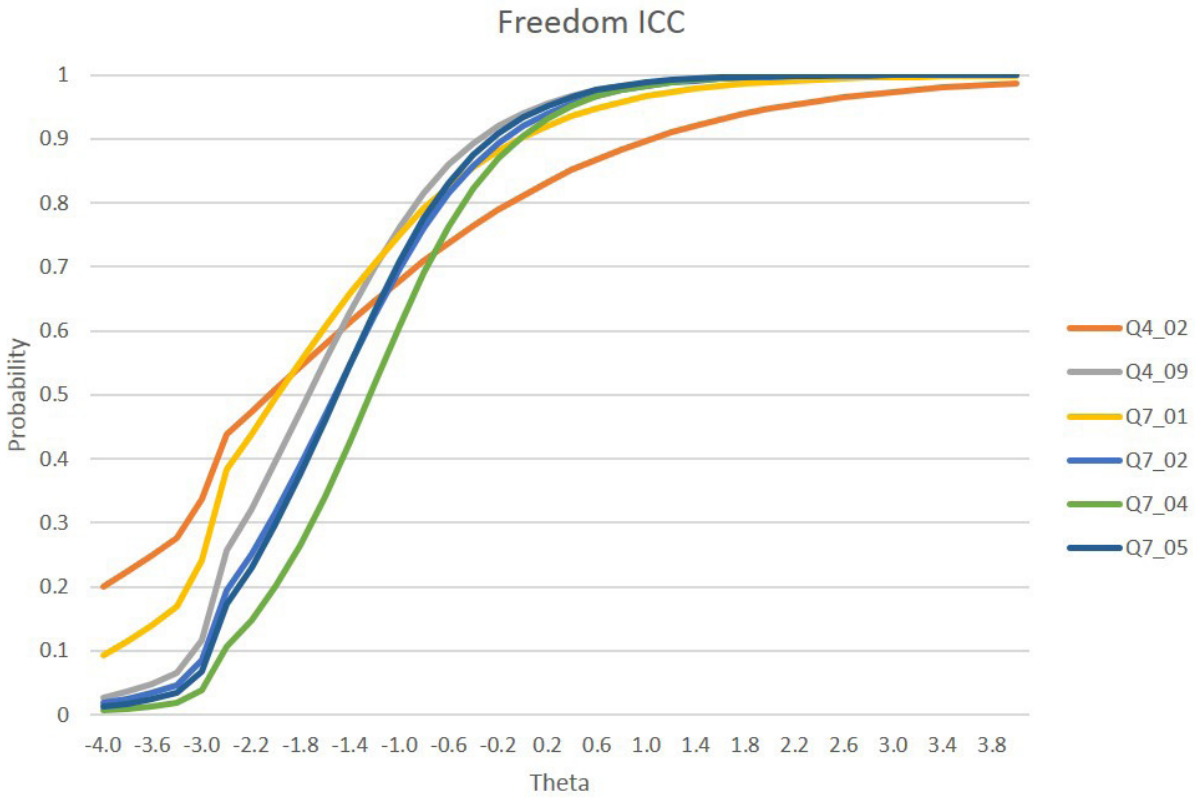

Figure 6. Item characteristics curve: EL items in freedom construct.

Improved CFA

Tables TA8-1 to TA9-3 outline the correlations among the items in the improved CFA within each of the three constructs for both the EC and EL levels. Tables TA10 and TA11 provide item loadings and standard errors for the improved EC and EL CFA models. All the structure paths in the improved model are significant for both EC and EL. Only one curriculum path in the improved EC model is significant, and all the curriculum paths in the improved EL model are nonsignificant. All the freedom paths in the improved EC model are significant. All but one freedom paths in the improved EL model are significant.

Table TA8-1

Improved EC CFA Model: Correlations Among Items in Structure Construct

Items in structure construct	1	2	3	4	5	6
1. Children give lessons to one another.	–	.24***	.03	.17**	.12	.20**
2. Observation is used for daily lesson planning.		–	.40***	.26***	.22***	.24***
3. Children's activities are recorded each day.			–	.24***	.27***	.21**
4. There is a 3-hour uninterrupted work period.				–	.23***	.24***
5. Lessons are mostly given to individuals.					–	.22***
6. Are evenly spread across at least a 3-yr age span.						–
M	3.35	3.48	3.35	3.13	3.32	3.15
SD	0.82	0.74	0.84	0.92	0.80	1.01

**$p < .01$; ***$p < .001$.

Table TA8-2

Improved EC CFA Model: Correlations Among Items in Curriculum Construct

Items in curriculum construct	1	2	3	4	5	6	7	8
1. A full set of Montessori materials is available.	–	.41***	.23***	.33***	.45***	.17**	.26***	.21**
2. A polishing activity is available.		–	.08	.32***	.39***	.28***	.26***	.22***
3. Classroom books feature realistic stories.			–	.21***	.26***	.25***	.28***	.18**
4. Children regularly prepare food.				–	.20**	.35***	.37***	.34***
5. Older children do golden bead addition.					–	.26***	.21**	.27***
6. Care for classroom plants.						–	.34***	.34***
7. Walk on the line carrying objects.							–	.30***
8. Garden in a designated area.								–
M	3.66	3.42	3.45	3.09	3.47	3.56	3.17	3.08
SD	0.69	0.93	0.72	1.01	0.90	0.78	1.01	1.09

**$p < .01$; ***$p < .001$.

Table TA8-3

Improved EC CFA Model: Correlations Among Items in Freedom Construct

Items in freedom construct	1	2	3	4
1. May choose to work alone or with others.	–	.33***	.39***	.25***
2. Decide where they will work.		–	.48***	.25***
3. Choose their work/activities.			–	.43***
4. Determine how long to work with an activity.				–
M	3.70	3.73	3.73	3.68
SD	0.53	0.51	0.49	0.58

***$p < .001$.

Table TA9-1
Improved EL CFA model: Correlations among items within Structure construct

Items in Structure construct	1	2	3	4	5	6	7
1. Problem solving for off-task behavior.	–	.29**	.21**	.21**	.15	.10	.33***
2. 1-on-1 meetings at least every 2 weeks.		–	.43***	.17*	.24**	.19**	.16*
3. Observation used for daily lesson planning.			–	.18*	.37***	.30**	.31***
4. Children record activities in work journals.				–	.09	.19*	.28**
5. There is a 3-hour uninterrupted work period.					–	.26**	.48**
6. Children give lessons to one another.						–	.29***
7. Most lessons given in groups of 2-5 children.							–
M	3.49	3.03	3.42	3.53	3.48	3.31	3.34
SD	0.69	0.98	0.66	0.85	0.81	0.67	0.77

*$p < .05$; **$p < .01$; ***p< .001.

Table TA9-2
Improved EL CFA model: Correlations among items within Curriculum construct

Items in Curriculum construct	1	2	3	4	5	6	7	8	9
1. Children correct their own work.	–	.17*	.20*	.29***	.30***	.26***	.29***	.28***	.33***
2. Great Lessons/Stories are given each fall.		–	.41***	.45***	.31***	.23**	.18*	.15	.22*
3. Use human fundamental needs charts.			–	.36***	.45***	.48***	.41***	.35***	.35***
4. Most instruction with Montessori materials.				–	.27***	.27***	.34***	.22***	.33***
5. Make history timelines.					–	.51***	.36***	.32***	.38***
6. Repeat Montessori science experiments.						–	.35***	.44***	.40***
7. Have access to full set Montessori materials.							–	.33***	.23**
8. Take part in community service projects.								–	.37***
9. Children regularly prepare food.									1
M	3.16	3.47	3.17	3.62	3.07	3.11	3.70	3.18	2.81
SD	0.70	0.85	0.90	0.65	0.90	0.88	0.60	0.82	1.11

*$p < .05$; **$p < .01$; ***p< .001.

Table TA9-3

Improved EL CFA model: Correlations among items within Freedom construct

Items in Freedom construct	1	2	3	4	5	6
1. Children decide when to have snack.	–	.28***	.19**	.13	.19*	.20*
2. Children make classroom rules/ guidelines.		–	.34***	.29***	.28***	.25***
3. Do research based on interests.			–	.32***	.23**	.32***
4. Choose their work/activities.				–	.40***	.34***
5. Determine how long to work with activity.					–	.47***
6. Decide where they will work.						–
M	3.51	3.68	3.57	3.51	3.50	3.62
SD	0.90	0.67	0.58	0.58	0.63	0.62

*$p < .05$; **$p < .01$; ***p< .001.

Table TA10

EC Item Loadings on Each Factor in the Improved CFA Model

Variables	Unstandardized loadings	Std. err	Z-value	Sig	Standardized loadings
Factor 1. Structure					
Q4_06	0.43	0.13	3.34	<.001	0.53
Q6_01	0.49	0.12	4.03	<.001	0.66
Q6_02	0.52	0.13	4.06	<.001	0.62
Q6_03	0.51	0.20	2.48	.01	0.55
Q6_04	0.44	0.11	3.90	<.001	0.55
Q7_07	0.46	0.11	4.31	<.001	0.45
Factor 2. Curriculum					
Q4_01	0.40	0.19	2.09	.04	0.58
Q4_07	0.52	0.30	1.76	.08	0.56
Q6_06	0.32	0.21	1.54	.13	0.45
Q6_07	0.73	0.50	1.47	.14	0.72
Q6_08	0.34	0.18	1.95	.05	0.39
Q7_03	0.33	0.23	1.41	.16	0.42
Q7_08	0.80	0.48	1.67	.09	0.80
Q7_10	0.48	0.32	1.49	.14	0.44
Factor 3. Freedom					
Q7_01	0.32	0.07	4.82	<.001	0.59
Q7_02	0.40	0.09	4.44	<.001	0.79
Q7_05	0.39	0.10	3.85	<.001	0.79
Q7_06	0.33	0.10	3.35	<.001	0.57

Table TA11

EL Item Loadings on Each Factor in the Improved CFA Model

Variables	Unstandardized loadings	Std. err	Z-value	Sig	Standardized loadings
Factor 1. Structure					
Q4_07	0.24	0.10	2.26	.02	0.34
Q4_08	0.63	0.12	5.12	<.001	0.65
Q6_02	0.48	0.08	6.00	<.001	0.72
Q6_05	0.45	0.13	3.49	<.001	0.53
Q6_06	0.49	0.07	6.58	<.001	0.61
Q6_07	0.42	0.08	5.00	<.001	0.62
Q6_08	0.42	0.08	5.10	<.001	0.54
Factor 2. Curriculum					
Q4_11	0.43	0.47	0.91	.36	0.61
Q6_01	0.49	0.50	0.97	.33	0.57
Q6_03	0.53	0.48	1.10	.27	0.59
Q6_09	0.44	0.50	0.88	.38	0.66
Q7_07	0.60	0.58	1.03	.30	0.67
Q7_09	0.57	0.55	1.04	.30	0.65
Q7_10	0.33	0.37	0.87	.38	0.55
Q7_11	0.47	0.45	1.06	.29	0.58
Q6_10	0.71	0.67	1.05	.29	0.64
Factor 2. Freedom					
Q4_02	0.62	0.11	5.75	<.001	0.69
Q4_09	0.45	0.13	3.55	<.001	0.68
Q7_01	0.41	0.15	2.77	.01	0.71
Q7_02	0.42	0.13	3.10	<.001	0.72
Q7_04	0.29	0.15	1.93	.05	0.46
Q7_05	0.30	0.15	2.00	.05	0.49