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Developing Instruments to Measure Montessori Instructional Practices

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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.

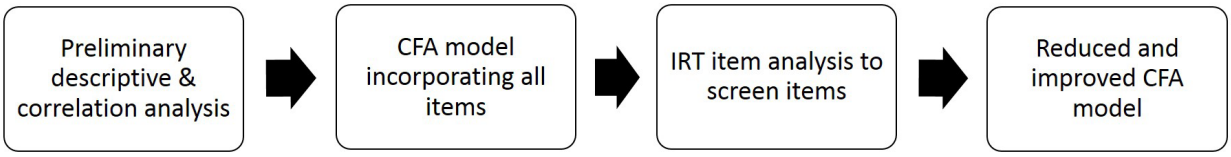

Figure 1. Analysis process for development of instruments.

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.

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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.

References

Standards

AMI/USA = Association Montessori International/USA. (2009). *AMI/USA Montessori school standards.* Alexandria, VA: AMI/USA.
AMS = American Montessori Society. (2014). AMS school accreditation standards and criteria.
MAFL = Montessori Australia Foundation Limited (2012). Montessori National Curriculum. *The NAMTA Journal, 37*(1).
NCMPS = National Center for Montessori in the Public Sector. (2015). Essential elements on Montessori practice in the public sector.
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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

*Aligned with inputs from the Logic Model for Montessori Education (Culclasure, Daoust, Morris Cote, & Zoll, 2019).
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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