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Contents

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From the Editor

This issue of the *Journal of Montessori Research* includes two powerful articles that address important issues in the field: reading achievement and cognitive development. Also in this issue is a review of six practitioner studies which reflect these professionals' efforts to address very real challenges they face in their classrooms and schools.

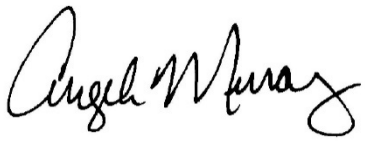
In the first article, Katie E. Brown, Leslie Woodford, and Kelly Powell share the results from their study of reading achievement in public Montessori schools in Arizona. The study was a collaborative effort to comply with legislation in the state requiring use of evidence-based reading curricula in public schools. In the study, the authors compare standardized state reading test scores of public Montessori students with those of students in traditional public schools across the state. They found Montessori students do at least as well as if not better than the comparison group, with students who have more Montessori experience showing even stronger outcomes.

The second article is a critical literature review by Laura K. Foster, examining the impact of classroom design on attention, regulation, and learning in early childhood education. In examining how intentionally prepared environments support cognitive development, Foster draws on neuroeducational concepts in combination with Montessori pedagogy to outline implications for educational policy, teacher preparation, and future empirical studies.

This issue concludes with the most recent installment of the *JMR* annual feature, "Rediscovering the Child," which is a review of practitioner research submitted to graduate teacher preparation programs. This year the review looks at six studies that address practitioners designing interventions to enhance life skills such as focus and engagement, to improve academic skills in reading and math, and to increase teacher retention.

I wish all of our readers a safe and happy Thanksgiving, and hope this issue provides some important insights for your own professional development and research.

Sincerely,



Angela K. Murray, PhD
Editor, *Journal of Montessori Research*
Chair, AERA Montessori Education SIG

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Reading Achievement in Arizona Public Montessori Schools

Katie E. Brown, National Center for Montessori in the Public Sector
Leslie Woodford, Khalsa Montessori School
Kelly Powell, Arizona Charter Schools Association

Keywords: *reading, Montessori, literacy, reading achievement, science of reading*

Abstract: In recent years, many state legislatures in the United States have implemented legislation and regulations requiring public schools to use evidence-based reading curricula. This study of reading achievement in public Montessori schools in Arizona was conducted to comply with one such piece of legislation. It compares public Montessori students' standardized state reading test scores to those of traditional public school students statewide. Through descriptive statistics and *t*-tests on aggregate measures, as well as simple regression, we demonstrate that students receiving Montessori reading instruction perform as well as or better than the comparison group in absolute terms. The longer students remain in the Montessori setting, the better they perform. This is also true for special education students, whose reading test scores after three or more years in a public Montessori program were indistinguishable from the general population. These results suggest Montessori instruction works as well or better than other reading curricula in use throughout the state to produce favorable results on Arizona's reading assessment, with noteworthy outcomes for students receiving special education services.

As of August 2024, 39 states in the United States have passed "science of reading" legislation: laws requiring schools to use evidence-based programs for reading instruction (Schwartz, 2024). Specific requirements of these laws vary by state. In Arizona, the policy allows schools to select any "evidence-based" reading curriculum for kindergarten through eighth grade (Arizona Department of Education, 2020). The U.S. Department of Education (USDE, n.d.) cites the definition of "evidence-based practices" as "activities, strategies, and interventions [that] are derived from or informed by objective evidence—most commonly, education research or metrics of school, teachers, and student performance." Because the Montessori Method de-emphasizes formal assessment (Lillard, 2017), such as end-of-year standardized tests, there is a philosophical mismatch between the push toward evidence-based instruction and this particular pedagogy. Thus, administrators of public schools utilizing Montessori instruction have found themselves needing

Figure 1
Rhyming Sound Objects. Photo by the authors.

to justify their pedagogical methods, using assessments that may not align with this constructivist approach to teaching and learning (National Center for Montessori in the Public Sector, 2019).

Montessori education is a popular school choice option, with 26 public schools offering Montessori programs in Arizona (National Center for Montessori in the Public Sector, n.d.). Although scholars argue that the Montessori Method aligns with the precepts of the science of reading (Zoll et al., 2023), the Arizona Department of Education did not initially list Montessori instruction as an evidence-based reading curriculum. In order to meet the requirements of the reading legislation, an empirical study was needed of literacy outcomes produced by schools using the Montessori approach.

This study examines evidence as to Montessori methods' effectiveness in teaching students to read, and whether the results meet or exceed other reading instruction methods. The authors compare the empirical reading and language arts achievement of Arizona public Montessori schools with statewide averages to assess evidence supporting Montessori education as an effective approach to reading instruction. Given the widespread passage of science of reading policies (Schwartz, 2024) and the nationwide reach of the public Montessori movement (National Center for Montessori in the Public Sector, n.d.), the significance of this study extends beyond the borders of Arizona.

Overview of Montessori Approach to Reading

The Montessori approach has been employed worldwide for more than a century; however, since it has historically been implemented in small independent schools, there is less research about its effectiveness compared to other methods of instruction. Recent decades have seen significant growth in the public Montessori movement; at the time of this writing, almost 600 public schools in the United States utilize the Montessori Method (National Center for Montessori in the Public Sector, n.d.). As more students gain access to Montessori programs, the body of research surrounding Montessori education also grows.

There is reason to believe the Montessori approach to reading instruction should yield positive outcomes for children. Zoll et al. (2023) leverage Scarborough's (2001) Reading Rope framework to demonstrate how Montessori curricula for Early Childhood and Lower Elementary years align with best practices described as the science of reading. Scarborough imagines reading as the intertwining of multiple strands of knowledge and skills divided into two categories: *language comprehension*, including all background knowledge to understand the written word, and *word recognition*, which implies all of the skills needed to decode written language. Scarborough's Reading Rope has become synonymous

with the science of reading. The Montessori approach is a systematic, explicit, and multisensory approach that relies on concrete manipulative materials to represent abstract concepts. In their book *Powerful Literacy in the Montessori Classroom: Aligning Reading Research and Practice*, Zoll et al. (2023) document a strand-by-strand comparison, tying the threads of the Reading Rope concept to Montessori teaching materials and practices. They find the Montessori approach aligns closely with Scarborough's Rope to include phonemic awareness, decoding and encoding, vocabulary (inclusive of academic language), grammar and syntax, reading fluency and oral reading, and reading comprehension. This theoretical alignment suggests the Montessori approach includes the components of evidence-based reading instruction. The following examples show how Montessori materials support development of both language comprehension and word recognition.

Word Recognition

In the category of word recognition, Early Childhood students—children ages 3 and 4—use a variety of manipulative materials to learn sound and letter recognition skills. For example, in the I Spy game, Montessori teachers call out a sentence like, "I spy with my little eye something that starts with 'p.'" The teacher applies the phoneme—the sound of the letter P—rather than calling out the letter. The children then look around the room to find objects that start with that sound: paper, pencil, pushpin, and so on. As students' skills of sound recognition improve, they engage in similar activities using miniature objects. For example, the objects pictured in Figure 1 show bat/hat, mouse/house, and bee/tree. The objects are stored in the small basket pictured, and children match the rhyming object pairs.

Auditory games precede work with graphemes: written letters. Once children are able to identify sounds of words, they can begin learning the letters. Sandpaper letters are the first sets of Montessori materials students use for this, as the shapes of the letters stamped in sandpaper are mounted to small boards. Teachers systematically teach the sounds and shapes of letters by modeling the sound while tracing the shapes with their fingertips on the sandpaper letter boards as shown in Figure 2. Children practice repeating the sounds while tracing the shapes with their fingertips. Next, the teacher models replicating the letter shapes in a tray of sand and then students practice forming letters in the sand tray. After students have learned the shapes and sounds of the letters, they match small objects to the letters (see Figure 3). At first, they match objects by the initial sounds, and with practice they learn to sort objects by medial and final sounds as well (Brown et. al, 2024).

Figure 2

Sandpaper Letters with a Sand Tray. Photo by the authors.

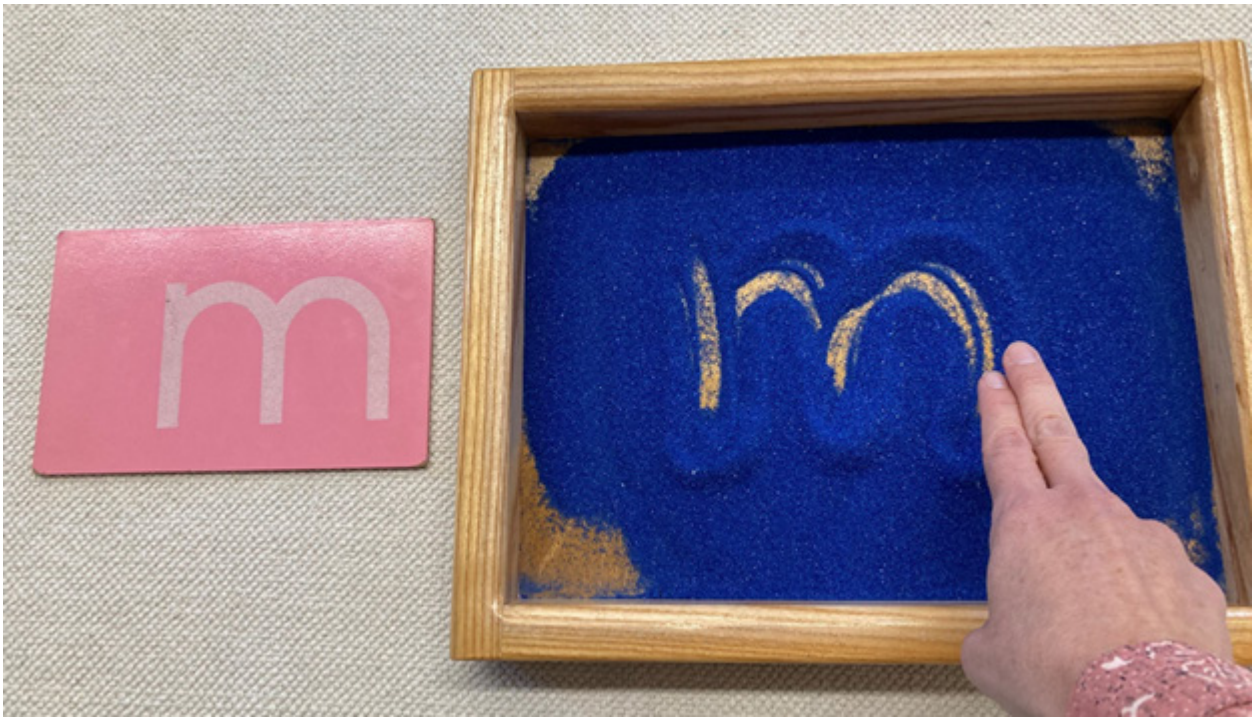
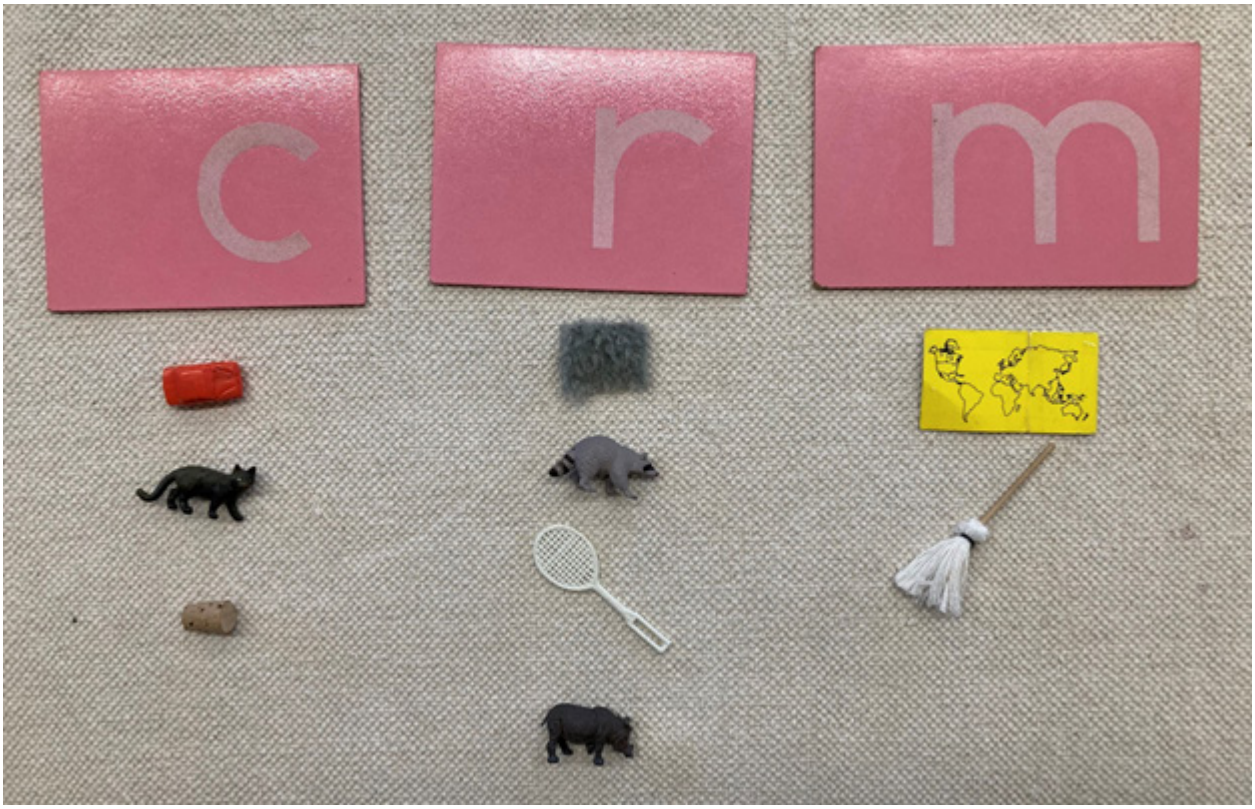


Figure 3
Sandpaper Letters with Sorted Objects. Photo by the authors.



Language Comprehension

To facilitate language comprehension, elementary students learn morphology—the study of parts of words including prefixes, suffixes, and root words—through systematic word study. Students are introduced to the concepts of prefixes and suffixes, by using objects and small cards. For example, in an introductory lesson, the teacher explains that the root of a word is represented by a tractor, as shown in Figure 4. The root "drives" the meaning of the word, and the suffix is like the trailer. Students might start with the root "farm" and the suffix "-er." Many Montessori classrooms use sets of movable Word Study cards informally called "The Montessori Skyscraper." A sample suffix assignment from this material is displayed in Figure 5. To complete the assignment, the student matches roots and suffixes from a mixed-up set of cards. The manipulative nature of the materials isolates the concept being taught. This helps students for whom handwriting might slow down the learning process (Brown et al., 2024).

The Montessori Skyscraper is comprised of more than 5,000 cards to teach the concepts of synonyms, antonyms, homonyms, compound words, capitals, periods, apostrophes, commas, quotations, alphabetizing, and dictionary guide words. Teachers use an introductory lesson—similar to the prior example with the tractor and trailer—that includes a story to teach each new concept.

Cultural Subjects

Children build background knowledge through age-appropriate lessons in Cultural Subjects: geography, history, botany, and zoology. For example, in the Lower Elementary classroom, students study the Timeline of Life (as shown in Figure 6), which introduces the history of the earth and its life-forms. The Timeline is a 9-foot poster-style visual that is rolled out onto the floor and includes moveable objects and images children can position in their correct locations along the printed timeline. Children are enthralled with the complex names of the various dinosaurs, other life-forms, and historic periods detailed in this material. The class spends many weeks studying, reading, and writing about the history of Earth.

The key in Montessori instruction is isolating the appropriate concept, and then using manipulative materials that allow students to learn and practice the

Figure 4
Introducing the Concept of Root and Suffix. Photo by the authors.

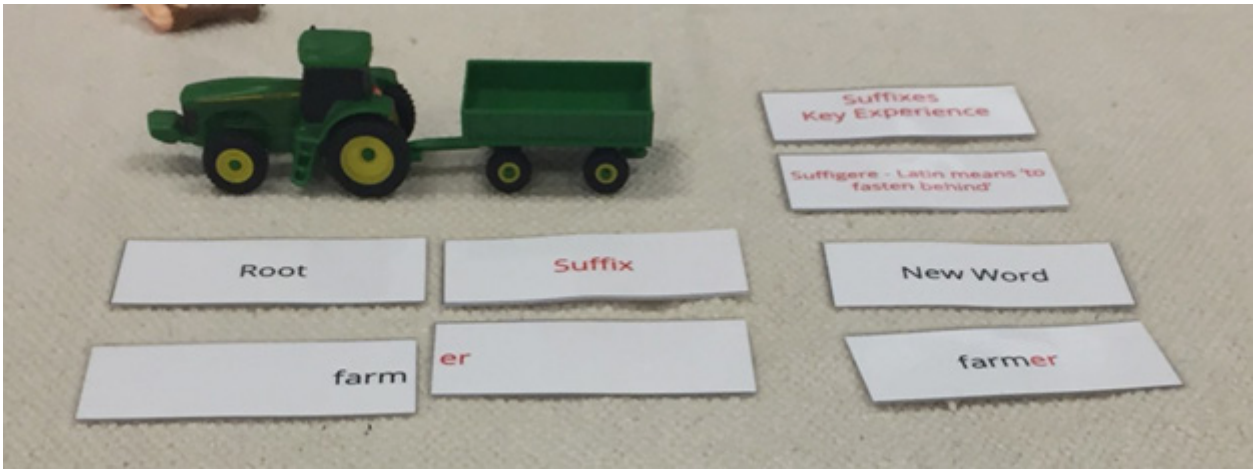
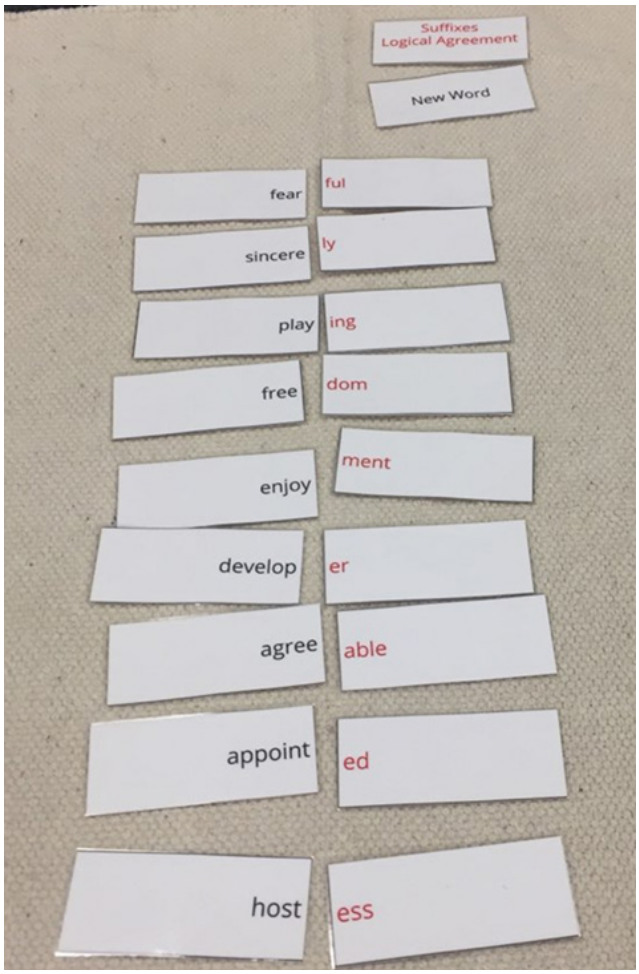


Figure 5
Systematic Practice of Roots and Suffixes. Photo by the authors.



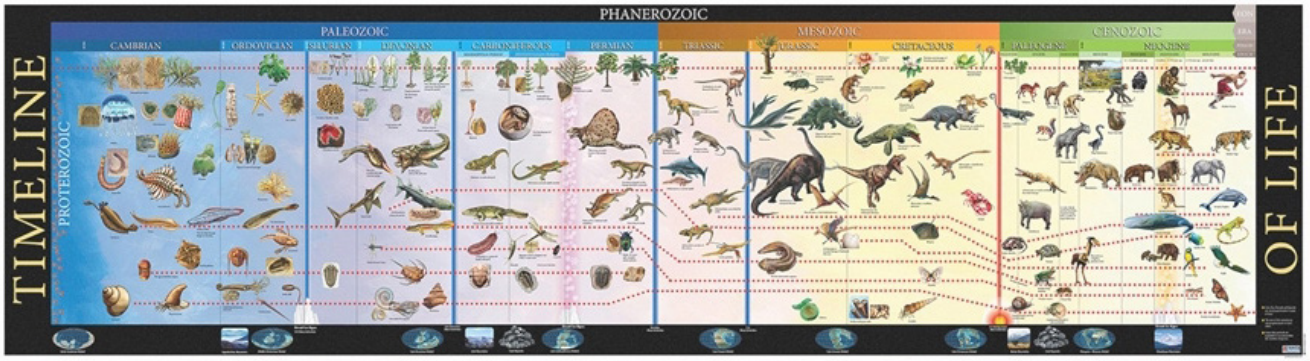
skills. Materials are selected for beauty and touchability, to draw children in and fulfill their natural curiosity. Those noted here are only a few examples of many materials used in Montessori classrooms. They demonstrate how Montessori education addresses the two main components required for skilled reading: language comprehension and word recognition. This instruction begins early with preschool-age children playing simple games that isolate letters and sounds, and culminates in third grade as children engage in in-depth reading assignments that involve students researching and writing about the history of Earth.

Literature Review

A review of the literature on reading outcomes for Montessori students suggests that, generally, Montessori students fare as well as or better in reading than their peers in other school settings. This literature includes large-scale studies of reading achievement for Montessori elementary and middle school students. In one of the most persuasive examples, Snyder et al. (2022) collected aggregated test score data from 195 Montessori schools in 10 states and compared each school with scores in its surrounding district. Overall, Montessori students were more likely to be proficient on state reading tests, and opportunity gaps were significantly smaller in Montessori schools. In a study somewhat comparable to the current one, Culclasure et al. (2018) studied outcomes for students in public Montessori schools throughout South Carolina and found Montessori students more

Figure 6

Timeline of Life. Image courtesy of Alison's Montessori and used with permission.



likely to perform at high levels on state English language arts (ELA) tests. Further, children from low-income backgrounds enrolled in public Montessori schools in South Carolina outperformed their peers in reading and showed more improvements than did demographically similar non-Montessori students. A recent meta-analysis (Randolph et al., 2023) found that Montessori education has a small but significant positive effect on literacy. Given that the Montessori approach de-emphasizes formal assessment such as standardized testing, the strong performance of Montessori students on these measures is particularly striking.

These large-scale studies document the benefits of Montessori education as viewed with a broad lens; additional investigation teases out specific benefits of Montessori instruction. Research suggests that early investment in Montessori instruction pays dividends for students later on, with Montessori students pulling ahead of their conventional school counterparts on tests of reading achievement after grade four (Mallet & Schroeder, 2015). Similarly, evidence shows exposure to Montessori education in early childhood may lead to stronger reading skills in elementary school, even for students who do not continue in a Montessori setting after preschool (Ansari & Winsler, 2020). This indicates Montessori instruction may provide a solid foundation in pre-literacy skills even before formal reading instruction begins and that these benefits may persist even after students exit a Montessori program.

Montessori instruction lays a strong foundation in the early years. Additionally, it benefits students from historically disadvantaged populations, including children of color and low-income students. Given the prevalence of inequitable academic outcomes in the United States, it is worth noting that racially minoritized students (Brown & Lewis, 2017; Debs & Brown, 2017; Fleming & Culclasure, 2023) and students from low-income families (Culclasure et al., 2018; Fleming & Culclasure, 2023) have demonstrated success after exposure to Montessori reading instruction. Lillard et al. (2017) found that children with low socioeconomic status most benefitted from Montessori education, and that by kindergarten, the typical socioeconomic opportunity gap had disappeared in Montessori classrooms.

Taken together, these studies suggest Montessori education can be an effective approach to reading instruction for a diverse population of children. However, none of these studies was accepted by the Arizona Department of Education as meeting requirements of the Arizona science of reading law. Specifically, the law called for studies that a) met the criteria to be considered Tier 1, Tier 2, or Tier 3 under the federal Every Student Succeeds Act, and b) demonstrate effectiveness in kindergarten through third grade (Arizona Department of Education, 2023). This study is designed to meet these requirements.

Though this research was conducted to meet a specific need in Arizona, it has application in other states as well. With the growing number of public Montessori schools in the United States, and the legislative push to adopt evidence-based curricula, many schools must defend the effectiveness of the Montessori approach in order to apply it. The challenge is confounded because the Method is not well understood outside of Montessori circles; thus, many such schools land in a position of having to either justify effectiveness of the Method or be forced to adopt teaching methods that do not align with Montessori principles. Research around Montessori implementation indicates a variety of child outcomes, including those related to executive function and early literacy skills, are better when the Montessori Method

is implemented with fidelity and not compromised by supplemental curricula (Lillard, 2012; Lillard & Heise, 2016). This study adds to the body of research that documents effectiveness of the model, thus allowing public schools to practice Montessori instruction with high fidelity.

Research Questions

This study was designed to address the following two research questions:

- How do Arizona public Montessori students perform on state English language arts (ELA) assessments after one, two, or three-or-more years of reading instruction compared to the general population of public students?
- How does the reading achievement of Arizona public Montessori students compare to state averages, controlling for student years of Montessori experience and demographics?

Methods

Research Design

A comprehensive set of student-level enrollment and demographic data, as well as state test data (Arizona Measurement of Educational Readiness to Inform Teaching [AzMERIT]) results for school year (SY) 2016–2019 for kindergarten through eighth grade, were provided by the Arizona Department of Education through a restricted-use data-sharing agreement and analyzed for this project. Prior to sharing, Arizona Department of Education staff cleaned the data. Though all enrollment, program, attendance, and test data were provided at the student level, student identifying information (such as names and ID numbers) was redacted. Specific data included enrollment and year-end code information, full academic year (FAY) enrollment information, student group information (race and ethnicity as well as program participation), school identifier, and test data for ELA and mathematics. For this study, data analysis is limited to ELA only. To determine the impact of Montessori instruction on students, state data records present the opportunity to do a quasi-experiment using Arizona's FAY indicator—which measures the number of years the student has remained at the school—as a measure of dosage for both the Montessori curriculum group and statewide comparison group.

Sample

The Montessori group was comprised of 4,781 students with state test results from 26 public Montessori schools in Arizona in 2019. Programs that comprise the Montessori group were identified by school mission statement and school name. Every effort was made to identify for the study group all schools that utilized Montessori methods, materials, and practices. All non-Montessori public elementary students in Arizona served as the comparison group for this study. Because the study was originally conducted as a program review to provide to the Arizona Department of Education, the whole universe of data was included rather than a sampling technique.

Measure

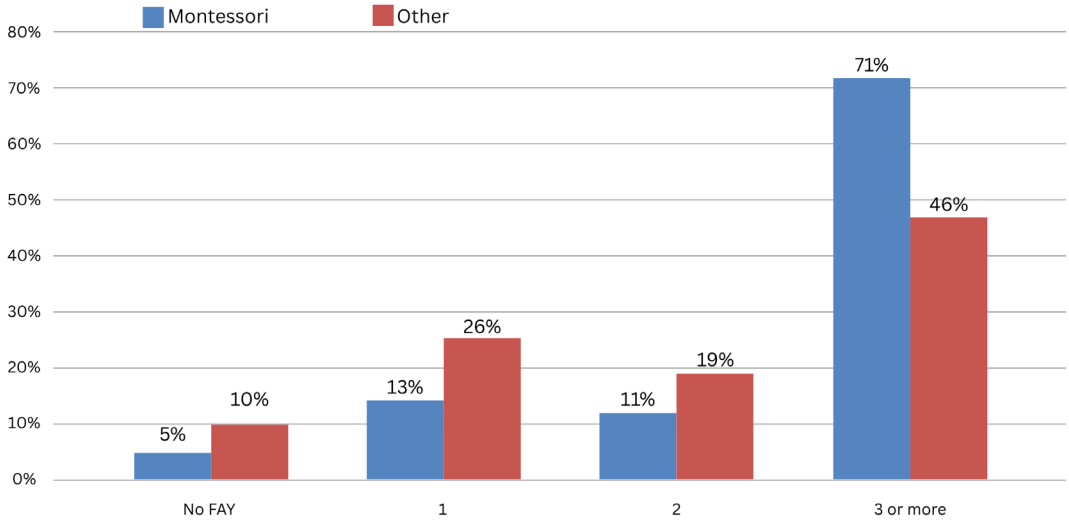
In Arizona, the universal outcome measure is the state test—AzMERIT. All Arizona public school students in grades three through eight took grade-level AzMERIT assessments in 2019 for English language arts (ELA) and mathematics. The tests are largely administered online, though a manual version of the test is available, and scores reflect student reading and writing performance. Although Arizona has changed the test name several times in the past decade, the state maintains utility of an item[1] pool that aligns with Common Core State Standards in mathematics and ELA. Arizona State Standards are based on Common Core with minor modifications. Only items that align with Arizona State Standards were used for the 2019 assessment (American Institutes for Research, 2020).

The key measures for this study are AzMERIT ELA scale scores and performance levels, as well as a state-created attendance stability measure: FAY, which represents the number of continuous full-academic years students remain enrolled in a school. For example, a FAY code of 0 indicates that the student has been at the school less than one school year (i.e. they entered the school in the middle of the school year). FAY 1 shows a student has been enrolled at the school for one full school year at the time of testing, FAY 2 indicates two years at the school, and FAY 3+ indicates a student has attended the school for three years or more. This data field is useful when considering the impact of a curriculum and an approach on outcome measures, since FAY is a basic quantification of Montessori dosage. The

[1] "Item" is test makers' word for "problem" or "question." Questions on the state assessment are "items."

Figure 7

Proportion of Students Full Academic Year (FAY) Status for the Montessori Group and All Others in the 2019 School Year



FAY field provides a quick measure of each student's history in a school setting and approximates "treatment" levels in a quasi-experimental sense. Though student participation in Montessori education is not randomly assigned, as in a true experiment, the FAY indicator gives us a measure as to what degree a student has been in the Montessori setting. This FAY measure helps compensate for the fact that this study lacks a measure of baseline equivalence. FAY is determined uniformly by the Arizona Department of Education, and is available to all schools in the state for review and correction through the course of school accountability modeling. FAY status for the Montessori and comparison groups is shown in Figure 7.

We measured the results of the AzMERIT for grades three through eight; however, because Arizona does not use a standardized statewide test in first or second grade, it is challenging to measure the effectiveness of early literacy programs. By reviewing FAY data, we were able to measure outcomes of literacy education in the three years preceding the state assessment, using a quasi-experimental design. The third-grade assessment results for students with three or more academic years of Montessori instruction reflect the outcome of Montessori reading instruction in the preceding years and provide some evidence as to its effectiveness.

Analysis

Through descriptive statistics and *t*-tests on aggregate measures, as well as simple regression, we demonstrate that Montessori curriculum and methods perform as well as or better than the comparison group in absolute terms, and student performance increases on state measures the longer students remain in the Montessori setting.

Results rely on standardized scale scores to ensure comparability across grade levels have tests of varying difficulty levels. Standardized scores, or *z*-scores, also allow for quick interpretation and comparison across groups and grades. For instance, a *z*-score of 0.0 indicates a group is at the state average for that grade level. *Z*-scores represent the number of standard deviations (SD) from the state average. Thus, a score of 0.68 indicates the group is 0.68 SD above the state average. A score of –0.13 is 0.13 SD below the state average for that grade.

Though multiple years of data were available, the majority of analyses was focused on data from the 2019 school year. This decision was driven by pragmatism with the availability of a three-year FAY measure, which allowed us to group students based on the number of years in Montessori or comparison group settings. We opted to use pre-COVID-19 data, because the pandemic interrupted regular educational instruction in most schools across the state. The restricted-use, student-

level data were aggregated and compared to historical school-level data from the National Center for Education Statistics (2025) to ensure accuracy of the records the state agency provided.

Results

Results for the AzMERIT ELA test are presented and discussed in the following paragraphs. Some basic demographics of the Montessori group, as well as Arizona as a whole, are provided in Table 1 for comparison purposes for the grade levels studied. Note that virtually all students in the Montessori group are enrolled in Montessori school by choice (even in the district schools). "Schools of choice" do not have attendance boundaries, and parents typically enroll and transport students to these schools because it is their choice. Sociopolitical factors in Arizona led to an artificially low reporting level of English language learners than would be recorded in other settings (Goldenberg & Rutherford-Quach, 2012).

Though the Montessori schools are demographically similar to the populations of surrounding local education agencies, there are some differences between the Montessori group and Arizona as a whole. Still, the Montessori group is far from being homogeneous as it represents students from all racial and ethnic backgrounds. In terms of special programs—English language development for multilingual learners and special education for students with disabilities—Montessori schools had fewer English learners but a comparable percentage of special education students.

Table 2 shows mean standardized ELA scores for students in the Montessori group and all schools in the comparison group. Due to the decline in student numbers in the middle grades in the Montessori group, grades six through eight were combined in the table below. The attrition occurs in schools of choice as students approach terminal grade levels and migrate to other schools to prepare for transition to middle or high school. Arizona had no public Montessori high schools in 2019.

State test scores were standardized within content area and grade level, so the mean standardized score (i.e., *z*-score) for an Arizona grade level is 0.0 with a standard deviation (SD) of 1.0. Based on the scores, it is apparent that Montessori schools on average across tested grades scored 0.46 SD higher than the comparison group. Montessori instruction in reading and writing as measured by Arizona's state test, AzMERIT, was associated with significantly higher scores than state averages and showed moderate effect sizes in all grade groupings.

Table 1

Special Program Group Percentages in Study (SY 2019)

	Montessori	Arizona
Asian	2%	3%
Black	2%	5%
Hispanic	31%	47%
Multiple races	11%	6%
Native American	<2%	4%
Native Hawaiian	<2%	<2%
White	55%	36%
English language development	2%	6%
Free or reduced lunch program	17%	44%
Special education	12%	13%

Table 2

SY 2019 ELA Student Counts and Test Results by Grade Level Grouping (in Standardized Form)

	Montessori			Comparison (Arizona Statewide)			Significance Testing	
Grade Level	*N*	Score	*SD*	*N*	Score	*SD*	*t*	*p*
3	605	0.48	1.03	80,662	0.00	1.00	11.46	<0.001
4	534	0.40	0.94	84,529	0.00	1.00	9.83	<0.001
5	519	0.46	0.91	88,000	0.00	1.00	12.29	<0.001
6–8	985	0.49	0.95	259,425	0.01	1.00	18.12	<0.001
Total	2,643	0.46	0.96	512,616	0.01	1.00	26.52	<0.001

Note. Probability (*p*) is considered statistically significant at or less than 0.05.

Table 3
Impact of Attendance History in Arizona Montessori Schools on 2019 Standardized Test Scores

Attendance History	Montessori Group			Significance Testing	
	N	Score	*SD*	*t*	*p*
Not FAY	115	−0.01	1.04	0.10	0.92
FAY	2,528	0.49	0.95	25.93	< 0.0001
Total	2,643	0.46	0.96	24.63	< 0.0001

Table 4
FAY Level and Aggregate Performance of Montessori Students

	Montessori Group			Significance Testing			
FAY Level	*N*	Score	*SD*	*t*	Lower Bound	Upper Bound	*p*
0	115	−0.01	1.04	0.10	−0.20	0.18	0.92
1	342	0.24	0.98	4.53	0.14	0.34	<0.0001
2	295	0.24	1.01	4.08	0.12	0.36	<0.0001
3+	1,891	0.57	0.92	26.94	0.53	0.61	<0.0001
Total	2,643	0.46	0.96	24.63	0.42	0.50	<0.0001

Also worth noting, the state average standardized score was not 0.0 since some students left Arizona schools between the date of testing and the end of the school year. Therefore, a slightly higher state average of 0.01 was apparent for the 512,616 students comprising the comparison group.

Full Academic Year

FAY is central to the Arizona accountability formula for determining school quality. FAY is used widely in Arizona and elsewhere to ensure that the students who "count" in accountability measures participated meaningfully in a school setting for the state test results to serve as an indicator. Compared to statewide FAY numbers as shown in Figure 7, the Montessori group is more stable with 71% of students identified as FAY3+, whereas only 46% of the comparison group were FAY3+. This pattern is typical with schools of choice. Parents select a school, usually in the early primary grades, and commit to the school until the student ages out of a terminal grade level.

Averaged across grade levels, students present for the full academic year fared better on standardized state test scores than did their non-FAY counterparts for both the Montessori group and comparison group. Students receiving one or more full years of Montessori instruction and methods outperformed their comparison group peers. Indeed, the comparison group performed on average roughly equivalent to non-FAY Montessori students (−0.01).

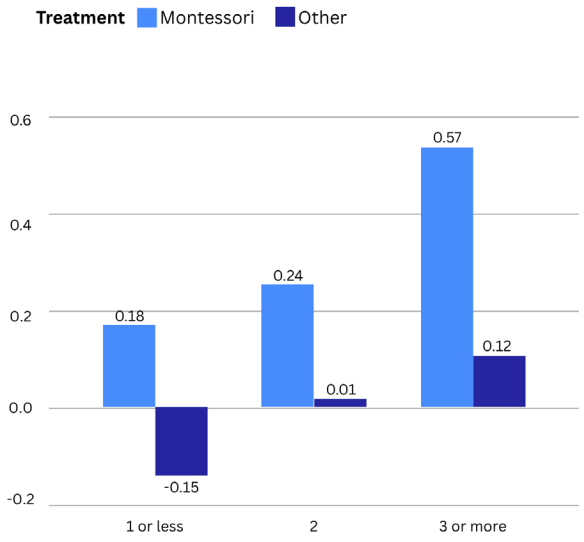
New Montessori students are similar to the comparison group. In contrast to the comparison group, with a mean score of 0.0 and SD of 1.0, the 2019 Montessori scores show significant differences for all levels of FAY, except FAY 0. Comparing the non-FAY Montessori group to the larger Arizona statewide context, no significant difference ($p = 0.92$) was found. Considering these students are new to Montessori schools but have transferred from the general Arizona public school population, this result is not surprising but meaningful. Indeed, given the significant impact of Montessori curricula on FAY students ($p < 0.0001$), this demonstrates an interesting pattern: Students enter Montessori schools statistically indistinguishable from the Arizona average, but score significantly higher after they attend a Montessori school for at least one full academic year. This difference is shown in Table 3.

In comparing these two groups' standardized ELA scores by FAY and grade level, researchers ascertained that students achieve at higher levels the longer they remain in the Montessori setting. All grade groupings (grades three, four, five, and six through eight) achieved higher standardized scores in the FAY 3+ group as compared with all other levels of FAY in all years, as presented in Table 4.

Though still well below the levels of the Montessori group, FAY 3+ students in the comparison group also had higher scores as compared to those with lower FAY levels. Also apparent from the scores is that though one

Figure 8

School Year 2019 Standardized Test Results for All Students by Full Academic Year (FAY) Status, Comparing the Montessori Group with the Statewide Comparison Group



or two full academic years in the Montessori setting significantly impacts student performance, with good effect sizes of 0.24, students who remain in a Montessori setting for three or more years benefit most (0.57). This pattern is evident in Figure 8.

The gap between the Montessori group and others is sizable and consistent. Though the metric of standard deviation units may not naturally conjure the magnitude of difference Montessori schools make, the results of other groups (such as special education students, as detailed in the following section) help provide additional context and interpretation to these analyses.

Special Populations

Montessori methods show promise for special populations, such as special education students, as detailed in Table 5. Special education (SPED) students are a diverse group, and student-level disability category details were not available in the restricted-use datasets. But from the 2019 data, the Montessori group had a proportionate and sizable SPED count—369 students, or 14% of tested students, compared to 12% in the statewide test data. The Montessori group saw an overall gap of 0.81 (−0.23 to 0.58) standard deviations between the SPED and other group, compared to a statewide gap of 1.05 (−0.91 to 0.14; see Table 5). Considering the FAY information, the gap between SPED and others in the Montessori sample seem to attenuate when "FAY 1 or less" students (a gap of 0.87) are compared to the FAY 3+ group (0.78). But the comparison group saw the gap grow from 1.01 in the "FAY 1 or less" to 1.09 standardized score units in the FAY 3+ group.

Based on Figure 9, stability in setting seems to serve special education students well; however, the impact is more dramatic in the Montessori group.

Since the FAY indicator truncates student history in the educational setting to only three years, it would be worth investigating whether or not the Montessori setting's impact measurably increases in years four, five, six and beyond, particularly considering the non-SPED data (see Table 6) with a similar dramatic increase in the FAY 3+ category. With no apparent drop-off in special

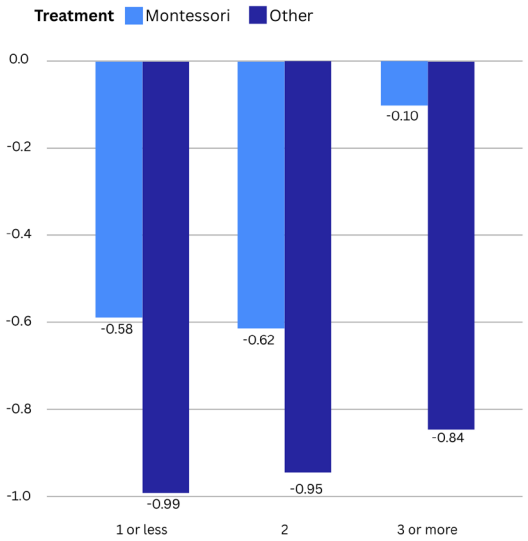
Table 5

Standardized Performance of Special Education and Non-Special Education Students in Montessori and Comparison Groups by Full Academic Year

	Non-Special Education		Special Education		Total	
	Score	Count	Score	Count	Score	Count
Montessori	0.58	2,260	−0.23	369	0.47	2,629
FAY 1 or less	0.29	388	−0.58	55	0.18	443
FAY 2	0.38	254	−0.62	41	0.24	295
FAY 3 or more	0.68	1,618	−0.10	273	0.57	1,891
Non-Montessori	0.14	444,776	−0.91	59,625	0.01	504,401
FAY 1 or less	0.02	149,834	−0.99	19,938	−0.13	169,772
FAY 2	0.14	85,910	−0.95	11,973	0.01	97,883
FAY 3 or more	0.25	209,032	−0.84	27,714	0.12	236,746
Total	0.14	447,311	−0.91	60,523	0.01	507,834

Figure 9

School Year 2019 Standardized Test Results for Special Education Students by Full Academic Year Status, Comparing the Montessori Group with the Statewide Comparison Group



education enrollment in the middle grades (the numbers are slightly higher in terms of student enrollees) the impact on performance at the FAY 3+ level is not likely due to students leaving Montessori schools.

It is noteworthy that there is no statistically significant difference between special education students with three or more years exposure to Montessori methods and curriculum as compared to the general Arizona population with all levels of FAY (−0.10 compared to 0.00).

Similar to the benefits special education students appear to receive by remaining in the Montessori setting, all students (the majority of whom do not have disabilities) experience their most dramatic results in the FAY 3+ category. This group was 71% of the Montessori sample in SY 2019, compared to 46% in the larger Arizona comparison group. Montessori programming retained students at a higher rate, and Montessori students performed better than non-Montessori students on the state ELA exam.

Table 6

Special Education Student Performance in Arizona Montessori Schools on 2019 Statewide ELA Test, Grades Three through Eight

	Montessori			Significance Testing	
FAY Category	*N*	Score	*SD*	*t*	*p*
1 or less	55	−0.58	0.94	4.58	< 0.0001
2 years	41	−0.62	1.07	3.71	0.0006
3 or more	273	−0.10	0.98	1.69	0.0929
Total	369	−0.23	1.01	4.37	< 0.0001

Regression Analysis

An ordinary least squares regression was conducted to evaluate the extent to which student subgroup status—FAY, English learner, special education, free/reduced-price lunch, race (dichotomously coded as White/non-White), and Hispanic group indicator (Hispanic/not Hispanic)—could predict ELA standardized test scores, with standardized test scores as the dependent variable and the following independent variables: FAY, English learner status, special education status, free/reduced-price lunch status, race indicator, and Hispanic group indicator. Though the amount of variance explained was quite modest ($R^2 = 0.268$, or about 27%), all variables in the model proved to be significant, and overall, the model was significant ($F = 31{,}451$ and $p < 0.001$). See Table 7 for the relative impact and significance of each variable in the model. The model was run for all 2019 test and student data ($n = 516{,}152$).

From the model, predicted scores that take into account demographic and student program differences

Table 7

Regression Model Coefficient Summary

			95% CI		
Variable	B	SE	LL	UL	*p*
Special education	−0.998	0.004	−1.0058	−0.9902	<.001
English learner	−0.836	0.005	−0.8458	−0.8262	<.001
Free/reduced lunch	−0.320	0.003	−0.3259	−0.3141	<.001
FAY	0.127	0.001	0.1250	0.1290	<.001
White	0.302	0.004	0.2942	0.3098	<.001
Hispanic	−0.085	0.003	−0.0909	−0.0791	<.001

were used to create a database of student-level predicted scores. For instance, the impact of FAY on scores for both the Montessori group and Arizona-wide comparison group was apparent. Predicted scores controlled for the advantage Montessori students may have with disproportionately higher numbers of FAY 3+ students. Predicted scores were subtracted from the standardized observed scores used throughout the descriptive data sections. The resulting measure estimates the difference between predicted scores and actual scores achieved by tested students in the 2019 school year, statistically accounting for any relative advantages students may have had because of their background. This suggests Montessori methods and instruction may have a positive effect on student language arts test scores independent of student background and experience.

Discussion

This study was designed to assess evidence of Montessori methods effectively teaching students to read and whether the results meet or exceed other reading instruction methods in use in Arizona. At the outset, we asked the following questions: How do Arizona public Montessori students perform on state English language arts (ELA) assessments after one, two, or three-or-more years of reading instruction compared to the general population of public students? Do Arizona public Montessori students perform as well or better than state averages, controlling for student years of Montessori experience and demographics?

Data from Arizona's state ELA tests indicate students in Montessori programs are well prepared to face the rigors of these assessments. Full academic year (FAY) data indicate families who chose a Montessori program for their student stayed with the program at higher rates than the general Arizona population and were rewarded with increasingly higher state test scores on the ELA exam. With regard to our first research question, we find increased dosage of Montessori education is associated with improved performance on ELA assessments, as compared with the general population of students. Although large sample sizes can lead to statistically significant results that are not actually meaningful in the real world, the differences in outcomes between Montessori and non-Montessori groups are substantial and not impacted by an overpowered sample.

With regard to our second research question, we find that across all grade levels and groups examined and explored for this paper, Montessori schools and the curricula and methods they employ with students outperform their statewide counterparts. Students who had not completed a full year of the Montessori curriculum in 2019 were statistically no different than the general population in Arizona. Enrollment stability appears to be associated with better ELA performance, and this relationship is more pronounced for students in Montessori settings. Students who remain in the same school for longer periods perform better, but students who remain in the same Montessori school for longer perform even better.

These results hold true even for the most academically challenged students—those with disabilities. Students receiving special education services in Montessori schools scored significantly higher than their peers in other settings across Arizona—a difference of nearly one standard deviation. It is plausible that the individualized and student-centered nature of Montessori instruction may be especially beneficial for these students.

As science of reading laws spread throughout the United States, reading instruction is becoming increasingly regulated by legislators rather than educators. These study results suggest Montessori reading instruction meets the criteria to be considered evidence-based under current Arizona legislation, and Montessori schools may not need to layer supplemental reading curricula on top of the Montessori approach. The Montessori approach to reading instruction may even be a source of promising practices.

Although formal assessment does not play a large role in Montessori pedagogy, public Montessori schools are subject to the same accountability requirements as any other public school. For Montessori programs in public schools to succeed and grow, more high-quality scholarship is needed to understand the outcomes these programs can produce for students—including for which students and under what specific circumstances. Because legislative and regulatory requirements constantly change, public Montessori practitioners and scholars of Montessori instruction must be flexible and adaptable.

Limitations

Several factors should inform interpretation and application of this work. Any standardized assessment provides only a snapshot of English language arts proficiency. AzMERIT may not fully capture all aspects of children's literacy development. This study utilized

data collected prior to the COVID-19 pandemic. The impacts of the pandemic on distance learning may mean replications of this work could yield different results. Although this quasi-experimental design leverages the FAY metric, this study did not include any measure of baseline equivalency between the Montessori and comparison groups. The Montessori and comparison groups may have differed in material ways not captured by our regression analysis. We attempted to statistically account for demographic differences between the Montessori and comparison groups, but these controls are often imperfect. Specifically, many public Montessori charter schools did not participate in the federally funded National School Lunch Program in 2019. As a result, the poverty level of these schools appears as zero, which may not accurately reflect the socioeconomic status of the student population. No attempt was made to document or account for the wide range of approaches to reading instruction in the comparison group, and we included no measure of Montessori fidelity for schools in this group.

Implications and Conclusion

Overall, the effect size magnitude of Montessori methods and curricula on standardized state test scores shows promise for other schools considering implementing Montessori instruction. The evidence suggests there may be significant positive impact from the Montessori approach on students learning to read and write proficiently, according to standards of Arizona's ELA test. Even for students with a single full academic year in a Montessori program, significant results were apparent with good effect sizes.

From the regression analysis, we learned Montessori methods and curricula were associated with positive student outcomes independent of student demographics and poverty, program differences, and years enrolled in a school (FAY), by comparing predicted student scores with actual observed scores from the 2019 school year.

The descriptive statistics, *t*-tests, and regression modeling indicate Montessori reading and English language arts instruction is an effective option for schools to teach students to read. After reviewing the data reported here, the state of Arizona has added Montessori as a vetted reading curriculum for Arizona schools.

Given the limitations of this study, future research could build on its findings by conducting a prospective study that includes baseline data on early literacy skill development across Montessori and non-Montessori students. It would also be fruitful to investigate how public Montessori schools teach reading, how program fidelity varies, and how this variability relates to student literacy outcomes. This work would add to the body of knowledge pertaining to Montessori education, reading achievement, and the science of reading.

Author Information

Katie E. Brown is director of research and professional learning at the National Center for Montessori in the Public Sector. She can be reached at katie.brown@publicmontessori.org. https://orcid.org/0000-0003-4633-6426

Leslie Woodford is curriculum coordinator at Khalsa Montessori School. She can be reached at lesliewoodford64@gmail.com.

Kelly Powell is senior vice president of research at the Arizona Charter Schools Association. He can be reached at kelly@azcharters.org.

References

American Institutes for Research. (2020). *Annual technical report: Arizona statewide assessment in English language arts and mathematics (2018–2019 school year)*. Arizona Department of Education. https://www.azed.gov/sites/default/files/2020/06/SY2018-19-AzMERIT-TechRpt-508.pdf?id=5ef6748c03e2b31340da5b1e

Ansari, A., & Winsler, A. (2020). The long-term benefits of Montessori pre-K for Latinx children from low-income families. *Applied Developmental Science, 26*(2), 252266.

Arizona Department of Education. (2023). *MOWR vetted programs guidance for new submissions* [Vendor document]. https://www.azed.gov/sites/default/files/2024/01/MOWR%20Vetted%20Programs%20Guidance.pdf

Arizona Department of Education. (2020). *2020–2021 Move on When Reading guidance—COVID*. https://www.azed.gov/sites/default/files/2020/07/2020-2021%20MOWR%20Guidance%20-%20COVID%20%282.pdf?id=5f19d0b403e2b30d4430f381

Brown, K., & Lewis, C. W. (2017). A comparison of reading and math achievement for African American

third grade students in Montessori and other magnet schools. *The Journal of Negro Education*, *86*(4), 439–448. doi:10.7709/jnegroeducation.86.4.0439

Brown, K., Powell, K., & Woodford, L. (2024). *Montessori: Evidence based reading curricula* [Data review]. Arizona Department of Education. https://www.azed.gov/sites/default/files/2024/07/Montessori%20an%20Evidence%20Based%20Reading%20Curricula.pdf

Culclasure, B., Fleming, D.J., Riga, G., & Sprogis, A. (2018). *An evaluation of Montessori education in South Carolina's public schools* [Evaluation report]. The Riley Institute at Furman University. https://files.eric.ed.gov/fulltext/ED622145.pdf

Debs, M. C., & Brown, K. E. (2017). Students of color and public Montessori schools: A review of the literature. *Journal of Montessori Research*, *3*(1), 1–15. http://dx.doi.org/10.17161/jomr.v3i1.5859

Fleming, D. J., & Culclasure, B. (2023). Exploring public Montessori education: Equity and achievement in South Carolina. *Journal of Research in Childhood Education*, 1–26. doi:10.1080/02568543.2023.2283202

Goldenberg, C., & Rutherford-Quach, S. (2012). The Arizona home language survey: The under-identification of students for English language services. *Language Policy*, *11*(1), 21–30. doi:10.1007/s10993-011-9224-5

Lillard, A. S. (2012). Preschool children's development in classic Montessori, supplemented

Montessori, and conventional programs. *Journal of School Psychology*, *50*(3), 379–401. doi:10.1016/j.jsp.2012.01.001

Lillard, A. S. (2017). *Montessori: The science behind the genius.* Oxford University Press.

Lillard, A. S., & Heise, M. J. (2016). An intervention study: Removing supplemented materials from Montessori classrooms associated with better child outcomes. *Journal of Montessori Research*, *2*(1), 16–26. doi:10.17161/jomr.v2i1.5678

Lillard, A. S., Heise, M. J., Richey, E. M., Tong, X., Hart, A., & Bray, P. M. (2017). Montessori preschool elevates and equalizes child outcomes: A longitudinal study. *Frontiers in Psychology*, *8*, 1783. doi:10.3389/fpsyg.2017.01783

National Center for Education Statistics. (2025). Elementary/secondary information system. *IES.* https://nces.ed.gov/ccd/elsi/

National Center for Montessori in the Public Sector. (n.d.). Montessori helps children reach their full potential in schools all around the world [About Montessori]. Retrieved November 3, 2025, from https://www.public-montessori.org/montessori/

National Center for Montessori in the Public Sector. (2019). *Montessori assessment playbook*. NCMPS Press.

Mallett, J. D., & Schroeder, J. L. (2015). Academic achievement outcomes: A comparison of Montessori and non-Montessori public elementary school students. *Journal of Elementary Education*, *25*(1), 39–53. https://pu.edu.pk/images/journal/JEE/PDF-Files/3_v25_no1_15.pdf

Randolph, J. J., Bryson, A., Menon, L., Henderson, D. K., Manuel, A. K., Michaels, S., rosenstein, d. l. w., McPherson, W., O'Grady, R., & Lillard, A. S. (2023). Montessori education's impact on academic and nonacademic outcomes: A systematic review. *Campbell Systematic Reviews*, *19*(3), e1330. https://doi.org/10.1002/cl2.1330

Scarborough, H. S. (2001). Connecting early language and literacy to later reading (dis)abilities: Evidence, theory, and practice. In S. Neuman & D. Dickinson (Eds.), *Handbook for research in early literacy* (pp. 97–110). Guilford Press.

Schwartz, S. (2024, January 25). The 'science of reading' in 2024: Five state initiatives to watch. *Education Week*. https://www.edweek.org/teaching-learning/the-science-of-reading-in-2024-5-state-initiatives-to-watch/2024/01

Snyder, A., Tong, X., & Lillard, A. S. (2022). Standardized test proficiency in public Montessori schools. *Journal of School Choice*, *16*(1), 105–135. Doi:10.1080/15582159.2021.1958058

U.S. Department of Education. (n.d.). Leveraging evidence-based practices for local school improvement. *USDE*. Office of Elementary and Secondary Education. Retrieved November 3, 2025, from https://www.ed.gov/teaching-and-administration/lead-and-manage-my-school/state-support-network/ssn-resources/leveraging-evidence-based-practices-for-local-school-improvement

Zoll, S., Feinberg, N., & Saylor, L. (2023). *Powerful literacy in the Montessori classroom: Aligning reading research and practice*. Teachers College Press.

Early Childhood Classroom Design: Integrating Montessori Principles with Neuroeducational Research

Laura K. Foster, Johns Hopkins University

Keywords: *allostatic load, attention, biophilic design, classroom design, content retention, early childhood education, embodied cognition, encoding, Montessori, neuroeducation, regulation*

Abstract: This critical literature review examines how classroom design influences attention, regulation, and learning in early childhood education (ECE). Combining Montessori pedagogy with Bronfenbrenner's theories as a conceptual framework, this review considers biopsychosocial impacts of physical classroom spaces. Experimental classroom research indicates the crucial first step of learning—encoding—may be disrupted in early classrooms cluttered with excessive visual stimuli that overwhelm children's attention. Drawing on neuroeducational concepts such as embodied cognition and allostatic load, this review highlights how intentionally prepared environments support attentional allocation, regulation, and encoding for content retention by emphasizing cognition's body-based and environmentally responsive nature. These findings challenge older models that view attention and regulation as fixed, child-based traits rather than capacities influenced through interaction with the environment. Additionally, decades of design research demonstrate exposure to nature in intentionally created spaces can reduce stress and improve cognitive functioning; yet this potential to enhance attention and learning in classrooms remains underexplored. By viewing classrooms dually as physical and cognitive spaces, this synthesis underscores the role of intentional design in promoting attentional allocation, regulation, and learning. These insights bridge the gap between Montessori practice and research, and offer a compelling rationale for optimizing ECE environments through a neurodevelopmental lens, with implications for educational policy, teacher preparation, and future empirical studies.

Although traditional measures of school readiness focus on literacy, numeracy, and physical development (Ghandour et al., 2024), educators often identify students' difficulties with self-regulation and attention as primary obstacles to children's readiness for school (Blair & Diamond, 2008; Eristi & Avci, 2021; Rimm-Kaufman et al., 2000). Attention-deficit/hyperactivity disorder (ADHD) has become one of the most common diagnosed conditions in young children (Danielson et al., 2024; Centers for Disease Control and Prevention, 2023; Mahone & Schneider, 2012). Research shows attention-related issues, such as distractibility and difficulty sustaining focus, are significant barriers to academic success in early childhood education (ECE), which encompasses birth through age 8 (Curby et al., 2018; Degol & Bachman, 2023).

Additionally, a growing body of cross-disciplinary research suggests physical classroom design plays a critical role in influencing children's attention and cognition. Studies show factors such as lighting, sound, color, visual displays, movement, and biophilic (nature-centered) elements can significantly impact attentional focus, well-being, and learning (Barrett et al., 2013; Brooks, 2010; Gaekwad et al., 2022; Godwin et al., 2022; Jeannin & Barthelemy, 2020; Kilbourne et al., 2017; Llorens-Gámez et al., 2021). Moreover, neurodivergent students experience additional sensitivity to overwhelming sensory input, demonstrating increasing externalized aggressive behavior (Baird et al., 2023), restricted participation (Cheryan et al., 2014), and greater distractibility and visual processing difficulties in autistic children and those with attentional differences (Hanley et al., 2017; Mallory & Keehn, 2021; Martin & Wilkins, 2021, Zazzi & Faragher, 2018).

Problem of Practice

Cumulatively, this body of research underscores the complexity of challenges early learning educators face, revealing a multidisciplinary and multifaceted problem of practice. Although the benefits of investing in ECE are well documented, empirical evidence indicates many early learning environments remain suboptimal for fostering effective learning. Specifically, visually dense settings, which are common in early childhood and elementary classrooms, deter children's attentional focus, reduce time spent on task, and negatively influence learning outcomes.

Figure 1

First-Grade Classroom at a Conventional Charter School

Note. Photo by Allison Shelley/Verbatim Agency for EDUimages (2017), licensed under CC BY-NC 2.0, https://www.flickr.com/photos/all4ed/36456780086

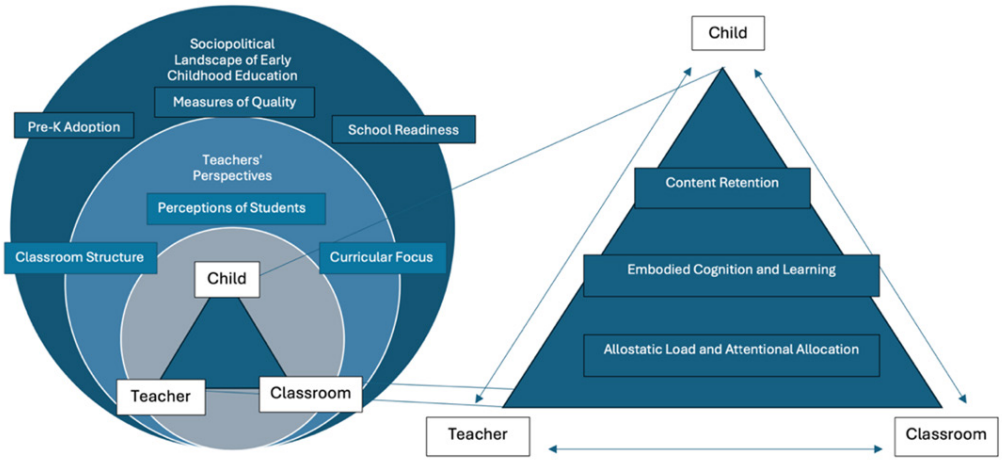
Rationale and Identified Gap in Literature

Despite robust findings in the science of learning that highlight the effectiveness of strategies such as interleaving, retrieval practice, and spaced learning for enhancing retention and understanding (Brown et al., 2014), these methods presuppose students have already successfully encoded the material. Cognitive scientists have long characterized the learning process as one of encoding, storage, and retrieval (Craik & Lockhart,1972; McDermott & Roediger, 2018); however, the foundational process of initial encoding is often undermined in early learning environments due to excessive visual clutter (Fisher et al., 2014; Godwin et al., 2022). Many classrooms, particularly those designed for young children, are saturated with prefabricated displays and dense visual stimuli (see Figure 1).

This proliferation of visual density may stem from a misapplication of Mayer's (2005) cognitive theory of multimedia learning, which supports dual-channel processing of visual and auditory information. Yet, there is limited empirical support for the effectiveness of these visually dense environments as inclusion of visual displays do not guarantee a learning effect (Guo et al., 2020). Instead, a growing body of evidence suggests they interfere with attentional allocation, stress regulation, and encoding, thereby undermining development and learning (Browning & Determan, 2024; Degol & Bachman, 2023; Dixon & Salley, 2007; Fisher et al., 2014).

Figure 2

Conceptual Framework of Early Learning Classroom Environments



The gap in current literature is twofold. First, although there is growing recognition of the importance of principles of the learning sciences, research has yet to fully explore how environmental design of early childhood classrooms impacts the initial encoding stage critical to content retention. Teachers are expected to design classrooms that promote learning, regulation, and sustained attention. However, interviews with teachers reveal they often lack empirical guidance on how to effectively design classroom environments and displays, and this leads them to depend on intuition, tradition, and social media rather than evidence-based strategies (Almeda et al., 2014; Lopez, 2020; Milo-Shussman, 2017).

Second, although adolescent students express preferences for calm, comfortable learning environments (Costa 2024; Students Speak, 2025), research rarely includes voices from children younger than 7 (de Leeuw et al., 2004). This lack of first-person accounts from young learners leaves a critical void in understanding how the physical classroom environment affects their cognitive and emotional engagement with learning.

To address this gap, this critical synthesis integrates insights from cognitive science, developmental psychology, architecture, and education to argue for a paradigm shift in early classroom design—one that is evidence-informed and child-centered. As Lillard (2023) suggests, reimagining the classroom through the lens of children's cognitive development, rather than institutional traditions, may be transformative.

Conceptual Framework

This review defines and examines how key factors—embodied cognition, allostatic load, and attentional allocation—affect encoding and content retention in visually dense early childhood settings. These factors are situated in the conceptual framework presented in Figure 2, which uses a novel approach to integrate two distinct theoretical perspectives .

The first framework is Bronfenbrenner's bioecological theory of child development (Bronfenbrenner & Ceci, 1994), which places the child at the center of multiple, nested systems of biopsychosocial influence. These systems include the microsystem representing the child's immediate environments such as family, school, and peers; the mesosystem, which reflects the interconnections among these settings; the exosystem encompassing external and virtual (Navarro & Tudge, 2023) contexts that indirectly affect the child; the macrosystem, which consists of cultural values, beliefs, and societal norms; and the chronosystem, which captures the influence of time and change. Together, these interconnected systems illustrate the multilayered, ongoing biopsychosocial interaction between child and contexts.

The second framework is Montessori's model of education (Montessori, 1912), which emphasizes the dynamic, triangular relationship between the child, the teacher, and the prepared environment (Cossentino & Brown, 2017). Within this model, the child is viewed

as an active learner who constructs knowledge through exploration and interaction with carefully tested prepared materials, which are designed to dually satisfy the child's natural inclination for play and academic curiosity (Lillard, 2021). In concert, the teacher as a guide, with the prepared environment, provides structure, order, and freedom within limits, allowing children to engage in purposeful activities that support autonomy, concentration, and intrinsic motivation (Tebano Ahlquist, 2023). When considered alongside Bronfenbrenner's bioecological theory, the Montessori framework offers a complementary perspective that highlights how environmental design, pedagogy, and developmental processes interact to shape children's learning experiences and outcomes in ECE settings.

Whereby many factors are acknowledged within this framework as part of a broader doctoral "scholarship of integration" (Boyer's [1990] academic model), the current literature synthesis focuses specifically on the elements within the triangle, which represent the neuroeducational experience of young children. Thus, this review underscores the critical connection between physical features of learning environments and learning outcomes. Advances in understanding the concepts of embodied cognition, allostatic load, and attentional allocation provide a robust framework for identifying the foundational factors that drive effective learning. By strategically optimizing educational environments to align with these principles, it becomes possible to create conditions that actively enhance students' content retention.

Embodied Cognition and Learning

Embodied cognition describes the inseparable connection between the environment, body, and brain (Kosmas et al., 2018). As Foglia and Wilson (2013) note, "there is no fracture between cognition, the agent's body, and real-life contexts … the body intrinsically constrains, regulates, and shapes the nature of mental activity" (p. 319). Gallagher's (2023) 4E model—embodied, embedded, extended, and enactive cognition—offers a powerful framework for understanding how young children learn through full-body engagement with their surroundings, particularly as they transition from home to school and begin forming identities as learners.

Central to this perspective is the concept of the "bodymind," a term with philosophical roots in the work of Husserl, Sartre, and Merleau-Ponty (Agostini & Francesconi, 2020), and extended into fields such as neuropharmacology (Pert, 1999), therapy (Rothschild, 2000), neuroscience (Damasio & Damasio, 2006), and dis/ability advocacy (Price, 2015; Nusbaum & Lester, 2021; Walker, 2021). This term also aligns with biopsychosocial theory (Engel, 1977) and bioecological systems theory (Bronfenbrenner, 1994), all of which reinforce the view that cognition is a dynamic process influenced by physical and social environmental factors. In classroom contexts, this means sensory inputs, such as color, density, and noise, directly influence children's regulation, attention, and learning capacity (Diamond, 2013; Fay-Stambach et al., 2014; Gaekwad et al., 2022). Thus, if attention is understood through a biopsychosocial lens, it encompasses neurobiological mechanisms as well as the social and environmental contexts in which children develop. This dynamic process illustrates how biological systems such as the autonomic nervous system and hypothalamic-pituitary-adrenal axis interact with interpersonal relationships, social expectations, and educational environments, thereby shaping not only the child's well-being but also their ability to attend, regulate, and engage in learning (Christensen et al., 2020; Lucente & Guidi, 2023).

Embedded cognition builds on this understanding by highlighting how the environment supports cognitive processing through affordances—objects like blocks, pencils, and digital tools—that enable children to externalize thinking through drawing, writing, and interactive media (Gallagher, 2023). *Enactive cognition* further emphasizes how physical expression, including gestures and body movements, supports meaning-making and communication (Schenck et al., 2022). In early childhood, intersubjectivity—children's tendency to perceive and respond through interaction with others—is a key enactive feature, exemplified in moments of physical attunement with caregivers (Gallagher, 2023). When classrooms become visually overstimulating, they may disrupt these foundational cognitive processes by overloading attention or suppressing natural sensory engagement.

This embodied perspective highlights how external stressors can lead to internal disruptions in both motor and emotional functioning (Gallagher, 2023; Immordino-Yang & Gotlieb, 2017). Conditions such as stress, sleep deprivation, or limited physical movement can impair executive functions. "Executive function" refers to the emergent ability to exert control in pursuit of specific goals (Doebel, 2020). As a result of disrupted executive functions, children may exhibit behaviors that could be misinterpreted as learning or attention disorders (Diamond, 2013). Internal states, influenced by learning

environment, play a critical role in influencing children's well-being and cognitive engagement (Fugate & Wilson-Mendenhall, 2022; Immordino-Yang, 2015).

Embodied learning, which applies these cognitive principles to educational settings, emphasizes the importance of sensorimotor experiences in memory and concept formation (Agostini & Francesconi, 2020; Shapiro & Stolz, 2019). In a review of literature, Fugate et al. (2018) found embodied learning strategies to be meaningful in a wide variety of educational domains, including writing, physics, and math. Additionally, Lozada & Carro (2016) found children who actively manipulate materials in Piagetian conservation tasks demonstrate a better understanding of quantity invariance than those who only observe. However, Western education systems often restrict such experiences, favoring conventional models of instruction that marginalize sensory exploration (Macedonia, 2019). As Macedonia explains, "children cannot be prevented from touching, dropping, smelling the objects and putting them in their mouths. Therefore, in the brain's language, a word must be represented as a sensorimotor network that mirrors all experiences collected to the concept" (p. 3). When early learning environments are structured to suppress movement and sensory engagement, often under the pressure of "schoolification," they undermine the natural learning processes of young children (Schunk et al., 2022; Shepard, 1997).

Additional research confirms sensory processing influences participation and engagement in learning activities (Sleeman & Brown, 2021), and that difficulties in sensory regulation, particularly among preterm preschoolers, are linked to deficits in executive function (Adams et al., 2015). Taken together, these findings reinforce the need to critically evaluate and redesign classroom environments. Visually dense, overstimulating settings not only fail to support the body-based nature of cognition but directly interfere with children's ability to attend, engage, and learn effectively.

Allostatic Load and Attentional Allocation

The learning sciences have long explored conditions that best support learning (Sawyer, 2014). Yerkes and Dodson (1908) first described an inverted U-shaped relationship between arousal and performance, suggesting low and high levels of arousal both hinder learning. This principle has been repeatedly confirmed and applied to areas such as executive function (Blair & Ursache, 2011; Neuenschwander et al., 2014). A helpful framework for understanding children's tolerance to sensory input is allostatic load, the cumulative burden of everyday stressors and significant life events (Lucente & Guidi, 2023). Conkbayir (2021) describes this as it relates to young children as, "alteration of stress hormones in response to experience, with consequent effects on emotions, attention, and executive function" (p.129). Thus, when environmental demands exceed a child's capacity to adapt, allostatic overload can occur, resulting in elevated cortisol, emotional dysregulation, attention difficulties, and memory impairment (Christensen et al., 2020; D'Amico et al., 2020; Lucente & Guidi, 2023).

The stress response is further intensified by systemic inequities; chronic exposure to poverty and racism increases cortisol levels in mothers as well as young children, with measurable negative effects on cognitive development and executive functioning (Blair et al., 2011). These findings challenge older cognitive models that frame attention and self-regulation as purely top-down skills to be trained (Diamond & Ling, 2019). In contrast, Tang et al. (2022) propose that nature exposure, flow states, and effortless engagement support cognitive outcomes through autonomic pathways.

For decades, architects and designers have studied how built environments influence human well-being. Foundational theories such as Ulrich's (1983) stress reduction theory and Kaplan's attention restoration theory (Kaplan & Kaplan, 1989; Kaplan, 1995) propose that exposure to nature can reduce stress and restore depleted attention. Building on these ideas, Albright (2015) suggests physical spaces meet bodily and psychological needs, highlighting a dynamic relationship between architecture and neuroscience. Empirical studies across various settings support these theories, confirming effects on cognitive, emotional, social, and behavioral well-being (Gaekwad et al., 2022; Gifford, 2013; Moll et al., 2022) Consequently, biophilic design elements such as natural light, open spaces, neutral color palettes, indoor plants, natural materials, and access to outdoor environments are intentionally incorporated into hospitality, medical, and commercial spaces to improve health and well-being.

Despite such applications, biophilic design in schools remains underexplored, particularly through the lens of allostatic load, thereby highlighting a key area for future research (Albright, 2015; Browning & Determan, 2024; Gaekwad et al., 2022). These insights reveal that classroom environments, if visually overwhelming or misaligned with children's stress regulation needs, can contribute to allostatic overload, ultimately impairing attention, executive function, and learning, particularly

for children affected by systemic inequities.

To build on this, understanding how specific classroom sensory demands compete for children's limited cognitive resources requires examining how attention is allocated, a process researchers have explored through eye-tracking and behavioral observation both in laboratory and real-world settings (Mahone & Schneider, 2012; Posner & Rothbart, 2018; Caldani et al., 2020; Dixon & Salley, 2007; Henderson & Ferreira, 2004; Keller et al., 2020; Turoman et al., 2021). Turoman et al. (2021) found that attention is shaped by goals, sensory salience, meaning, and predictability, emphasizing the need for holistic models that consider multisensory and contextual factors. Given children's still-developing attentional systems, external influences are especially significant (Posner & Rothbart, 2018).

Researchers Godwin and Fisher (2011; Fisher et al., 2013, 2014; Godwin & Fisher, 2011; Godwin et al., 2018, 2021, 2022) have collaboratively investigated for a decade the impact of visual density on learning. To operationalize attentional allocation in classrooms, their studies have manipulated the density of visual environments and tracked resulting eye movements, on-task behavior, and content retention. Each of their studies has demonstrated improved attentional allocation, on-task behavior, and stronger content retention in settings that are less dense. In their latest work, Godwin et al. (2022) contrasted laboratory classrooms with authentic classrooms to study habituation to density over time. They found only partial habituation to classroom visuals in a lab setting and no habituation in real classrooms. Despite consistent off-task behavior, attentional allocation varied, and real classrooms grew more visually dense as weeks passed. This finding aligns with the larger, paradoxical question raised by Fisher et al. (2014): Why are our youngest learners, with the least developed attentional control, placed in learning environments rich with potential sources of distraction?

Encoding for Content Retention

The persistent impact of visual density on attention and behavior also impacts initial encoding conditions, which directly affect content retention, a key metric increasingly prioritized in education policy and assessment (Willingham, 2015, 2021). In efforts to evaluate school effectiveness, economists and education researchers often focus on measurable outcomes, such as test performance (Brennan, 2023). Although there are various metrics to evaluate schooling, effectiveness

Figure 3

Early Childhood Classroom Utilizing Biophilic and Montessori Design

Note. Photograph from Montessori Māja, used with permission

is commonly operationalized in terms of content retention, typically measured through standardized tests (Hanushek, 2005; William, 2010). In 2024, the National Center for Education Statistics reported a decline of 7 points in reading and 14 points in mathematics on assessments administered to 13-year-olds during the past decade (Irwin et al., 2024). As a result, significant national pressure remains on schools to boost test scores and demonstrate academic improvement.

Disparities in test scores are already evident at the point of school entry (Burchinal et al., 2020; Ghandour et al., 2024) and can have lasting effects on students' educational trajectories and accumulated opportunities (Dearing et al., 2024). As a result, content retention has become a central focus in efforts to improve educational outcomes. The learning sciences have established that encoding and retaining content are possible only when children are fully able to attend to and process information (Craik et al., 1996; Posner & Rothbart, 2007). Brown et al. (2014) define encoding as "the process of converting sensory perceptions into meaningful representations in the brain" (p. 72). However, when the sensory environment is flooded with nonessential stimuli, encoding is impaired (Craik et al., 1996). Maximalist classroom designs, which often create visually dense, sensory-overloading environments, hinder effective encoding (Dixon & Salley, 2007; Keller et al., 2020; Rodrigues & Pandeirada, 2018).

This underscores the critical need for classroom environments that not only reduce visual and sensory overload but also promote the encoding process by

centering children's attentional focus. Maria Montessori's purposefully constructed classroom environment—the prepared environment—exemplifies how intentional design can positively influence student outcomes. Montessori spaces are grounded in principles that prioritize concentration, support sustained engagement, and promote sensory clarity (Haines, 2017). Carefully prepared to reduce distraction, Montessori environments feature natural light, open space, neutral color palettes, natural materials, and minimal visual clutter. A growing body of research confirms that students in Montessori environments experience positive outcomes, including improved academic performance, emotional regulation, and focused attention (Denervaud et al., 2019; Randolph et al., 2023; Phillips-Silver & Daza, 2018). Additionally, biophilic elements commonly used in Montessori and similar pedagogies have been associated with lower stress levels and enhanced cognitive functioning (Browning & Determan, 2024; Cha, 2023; Dadvand et al., 2015; O'Connor & O'Connor, 2024; Vella-Brodrick & Gilowska, 2022; Yang et al., 2019).

Discussion

The impact of classroom environments on attention, regulation, and learning is well documented but often overlooked in conventional preservice teacher training (Almeda et al., 2014; Godwin et al., 2018; Godwin & Fisher, 2011; Milo-Shussman, 2017). Teacher preparation programs frequently neglect the sensory and environmental aspects of classroom design, leaving educators ill-equipped to optimize learning spaces (Lopez, 2020). Consequently, teachers often default to familiar or trend-driven designs lacking a foundation in research-based practices (Almeda et al., 2014; Lopez, 2020). Lopez emphasizes this issue, noting that "the majority of teachers relied on the current culture that promotes the same types of displays that have continued to pervade classrooms for generations" (p. 85). As a result, many classrooms become visually cluttered and overstimulating, which disrupts students' abilities to focus, impairs regulation, and decreases learning by hindering encoding and content retention.

Montessori's approach offers a compelling alternative by centering attention and regulation through intentional classroom design. Based on her scientific observations, Montessori (1946) emphasized the "awakening of mental concentration" as essential to learning, achievable through prepared environments and materials (p. 78). She found that children's natural sense of order fosters responsibility and discipline when classrooms support independent engagement (Montessori, 1966, 1979). As the Montessori approach includes many layered aspects, such as specialized teacher training, a full complement of materials, uninterrupted work cycles, and other elements beyond the scope of this review, the research presented here supports this fundamental principle of physical classroom design. Importantly, this principle can be readily incorporated into more conventional classrooms through small-scale, practical adaptations (Debs et al., 2024), demonstrating that intentional environmental features can enhance attention, regulation, and learning outcomes even outside full-fledged Montessori settings.

Ultimately, classroom design is not simply aesthetic; the learning environment is a critical pedagogical tool that influences children's cognitive development. This approach moves beyond viewing attention and regulation as fixed traits or solely child-based challenges, instead framing these capacities as emergent through dynamic interaction with the learning environment. By grounding classroom environments in research and theory, educators and policymakers can transform everyday learning spaces into settings that foster attentional focus, regulation, and academic growth, making evidence-based improvements accessible even in traditional educational contexts.

Author Information

Laura K. Foster is a doctoral student at Johns Hopkins University. She can be reached at lfoste31@jh.edu.
https://orcid.org/0009-0000-9427-0754

References

Adams, J. N., Feldman, H. M., Huffman, L. C., & Loe, I. M. (2015). Sensory processing in preterm preschoolers and its association with executive function. *Early Human Development, 91*(3), 227–233. https://doi.org/10.1016/j.earlhumdev.2015.01.013

Agostini, E., & Francesconi, D. (2020). Introduction to the special issue "embodied cognition and education." *Phenomenology and the Cognitive Sciences, 20*(3). https://doi.org/10.1007/s11097-020-09714-x

Albright, T. (2015). Neuroscience for architecture. In S. Robinson & J. Pallasmaa (Eds.), *Mind in architecture: Neuroscience, embodiment, and the future of design* (pp. 197–217). The MIT Press. https://doi.org/10.7551/mitpress/10318.001.0001

Almeda, M. V., Scupelli, P., Baker, R. S., Weber, M., & Fisher, A. (2014). Clustering of design decisions in classroom visual displays. *Proceedings of the Fourth International Conference on Learning Analytics and Knowledge*. Association for Computing Machinery. https://doi.org/10.1145/2567574.2567605

Baird, A., Candy, B., Flouri, E., Tyler, N., & Hassiotis, A. (2023). The association between physical environment and externalising problems in typically developing and neurodiverse children and young people: A narrative review. *International Journal of Environmental Research and Public Health, 20*(3), 2549. https://doi.org/10.3390/ijerph20032549

Barrett, P., Zhang, Y., Moffat, J., & Kobbacy, K. (2013). A holistic, multi-level analysis identifying the impact of classroom design on pupils' learning. *Building and Environment, 59*, 678–689. https://doi.org/10.1016/j.buildenv.2012.09.016

Blair, C., & Diamond, A. (2008). Biological processes in prevention and intervention: The promotion of self-regulation as a means of preventing school failure. *Development and Psychopathology, 20*(3), 899–911. https://doi.org/10.1017/s0954579408000436

Blair, C., Granger, D. A., Willoughby, M., Mills-Koonce, R., Cox, M., Greenberg, M. T., Kivlighan, K. T., & Fortunato, C. K. (2011). Salivary cortisol mediates effects of poverty and parenting on executive functions in early childhood. *Child Development, 82*(6), 1970–1984. https://doi.org/10.1111/j.1467-8624.2011.01643.x

Blair, C., & Ursache, A. (2011). A bidirectional model of executive functions and self-regulation. In K. D. Vohs & R. F. Baumeister (Eds.), *Handbook of self-regulation: Research, theory, and applications* (2nd ed., pp. 300–320). The Guilford Press.

Boyer, E. L. (1990). *Scholarship reconsidered: Priorities of the professoriate*. [Special Report]. Jossey-Bass.

Brennan, R. L. (Ed.) (2006. *Educational measurement*. Rowman & Littlefield.

Bronfenbrenner, U. (1994). Ecological models of human development. *International encyclopedia of education, 3*(2), 37–43. https://www.ncj.nl/wp-content/uploads/media-import/docs/6a45c1a4-82ad-4f69-957e-1c76966678e2.pdf

Bronfenbrenner, U., & Ceci, S. J. (1994). Nature-nurture reconceptualized in developmental perspective: A bioecological model. *Psychological Review, 101*(4), 568–586. https://doi.org/10.1037/0033-295x.101.4.568

Brooks, D. C. (2010). Space matters: The impact of formal learning environments on student learning. *British Journal of Educational Technology, 42*(5), 719–726. https://doi.org/10.1111/j.1467-8535.2010.01098.x

Brown, P. C., Roediger III, H. L., & McDaniel, M. A. (2014). *Make it stick: The science of successful learning*. Belknap Press.

Browning, W., & Determan, J. (2024). Outcomes of biophilic design for schools. *Architecture, 4*(3), 479–492. https://doi.org/10.3390/architecture4030026

Burchinal, M., Foster, T. J., Bezdek, K. G., Bratsch-Hines, M., Blair, C., & Vernon-Feagans, L. (2020). School-entry skills predicting school-age academic and social–emotional trajectories. *Early Childhood Research Quarterly, 51*, 67–80. https://doi.org/10.1016/j.ecresq.2019.08.004

Caldani, S., Isel, F., Septier, M., Acquaviva, E., Delorme, R., & Bucci, M. P. (2020). Impairment in attention focus during the Posner cognitive task in children with ADHD: An eye tracker study. *Frontiers in Pediatrics, 8*. https://doi.org/10.3389/fped.2020.00484

Centers for Disease Control and Prevention. (2023, March 8). *Anxiety and depression in children: Get the facts*. CDC. https://www.cdc.gov/children-mental-health/about/about-anxiety-and-depression-in-children.html#cdc_disease_basics_res-resources

Cha, K. (2023). The moderating role of cortisol and negative emotionality in the effects of classroom size and window view on young children's executive functions. *Behavioral Sciences, 14*(1), 18. https://doi.org/10.3390/bs14010018

Cheryan, S., Ziegler, S. A., Plaut, V. C., & Meltzoff, A. N. (2014). Designing classrooms to maximize student achievement. *Policy Insights from the Behavioral and Brain Sciences, 1*(1), 4–12. https://doi.org/10.1177/2372732214548677

Christensen, J. S., Wild, H., Kenzie, E. S., Wakeland, W., Budding, D., & Lillas, C. (2020). Diverse autonomic nervous system stress response patterns in childhood sensory modulation. *Frontiers in Integrative Neuroscience, 14*. https://doi.org/10.3389/fnint.2020.00006

Conkbayir, M. (2021). *Early childhood and neuroscience: Theory, research and implications for practice*. Bloomsbury Academic.

Cossentino, J., & Brown, K. (2017). *What's going on in this (developmental) classroom: DERS working paper #1*. National Center for Montessori in the Public Sector. https://static1.squarespace.

com/static/57aa72bf59cc6881bc28d9e2/t/66a3bf11c6d70168aac29dfa/1722007314665/DERS+Working+Paper+%231.pdf

Costa, A. R. (2024). Homing into school to create the ideal classroom: Young people want to combine the best of home and school learning environments. *CoDesign*, *21*(1), 74–94. https://doi.org/10.1080/15710882.2024.2363925

Craik, F. I. M., Govoni, R., Naveh-Benjamin, M., & Anderson, N. D. (1996). The effects of divided attention on encoding and retrieval processes in human memory. *Journal of Experimental Psychology: General, 125*(2), 159–180. https://doi.org/10.1037/0096-3445.125.2.159

Craik, F. I. M., & Lockhart, R.S. (1972) Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, 11, 671–684. https://doi.org/10.1016/S0022-5371(72)80001-X

Curby, T. W., Berke, E. B., Blake, J. J., DeMarie, D., DuPaul, G. J., Flores, R. L., Hess, R. S., Howard, K. A., Lepore, J. C., & Subotnik, R. F. (2018). Kindergarten teacher perceptions of kindergarten readiness: The importance of social–emotional skills. *Perspectives on Early Childhood Psychology and Education*, *2*(2), 115–137. https://hdl.handle.net/2144/37852

D'Amico, D., Amestoy, M. E., & Fiocco, A. J. (2020). The association between allostatic load and cognitive function: A systematic and meta-analytic review. *Psychoneuroendocrinology*, *121*, Article 104849. https://doi.org/10.1016/j.psyneuen.2020.104849

Dadvand, P., Nieuwenhuijsen, M. J., Esnaola, M., Forns, J., Basagaña, X., Alvarez-Pedrerol, M., Rivas, I., López-Vicente, M., De Castro Pascual, M., Su, J., Jerrett, M., Querol, X., & Sunyer, J. (2015). Green spaces and cognitive development in primary schoolchildren. *Proceedings of the National Academy of Sciences*, *112*(26), 7937–7942. https://doi.org/10.1073/pnas.1503402112

Damasio, A., & Damasio, H. (2006). Minding the body. *Daedalus, 135*(3), 15–22. JSTOR. https://www.amacad.org/publication/daedalus/minding-body

Danielson, M. L., Claussen, A. H., Bitsko, R. H., Katz, S. M., Newsome, K., Blumberg, S. J., Kogan, M. D., & Ghandour, R. (2024). ADHD prevalence among U.S. children and adolescents in 2022: Diagnosis, severity, co-occurring disorders, and treatment. *Journal of Clinical Child and Adolescent Psychology*, *53*(3), 1–18. https://doi.org/10.1080/15374416.2024.2335625

Debs, M., Murray, A., & Kuh, L. (2024). *Montessori adaptations: Case studies of application and access*. American Education Research Association. https://doi.org/10.3102/2104881

de Leeuw, E., Borgers, N., & Smits, A. (2004). Pretesting questionnaires for children and adolescents. In S. Presser, J. M. Rothgeb, M. P. Couper, J. T. Lessler, E. Martin, J. Martin, & E. Singer (Eds.), *Methods for testing and evaluating survey questionnaires* (pp. 409–429). John Wiley & Sons. https://doi.org/10.1002/0471654728.ch20

Dearing, E., Bustamante, A. S., Zachrisson, H. D., & Vandell, D. L. (2024). Accumulation of opportunities predicts the educational attainment and adulthood earnings of children born into low- versus higher-income households. *Educational Researcher*, *53*(9), 496–507. https://doi.org/10.3102/0013189x241283456

Degol, J. L., & Bachman, H. J. (2023). Early self-control and sustained attention problems: Associations with youth achievement, motivation, and engagement. *Cognitive Development*, *65*, Article 101290. https://doi.org/10.1016/j.cogdev.2022.101290

Denervaud, S., Knebel, J.F., Hagmann, P., & Gentaz, E. (2019). Beyond executive functions, creativity skills benefit academic outcomes: Insights from Montessori education. *PLOS ONE*, *14*(11), Article e0225319. https://doi.org/10.1371/journal.pone.0225319

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*(1), 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Diamond, A., & Ling, D. S. (2019). Review of the evidence on, and fundamental questions about, efforts to improve executive functions, including working memory. In J. M. Novick, M. F. Bunting, M. R. Dougherty, & R. W. Engle (Eds.), *Cognitive and working memory training: Perspectives from psychology, neuroscience, and human development* (pp. 143–431). Oxford University Press. https://doi.org/10.1093/oso/9780199974467.003.0008

Dixon Jr., W. E., & Salley, B. J. (2007). "Shhh! We're tryin' to concentrate": Attention and environmental distracters in novel word learning. *The Journal of Genetic Psychology*, *167*(4), 393–414. https://doi.org/10.3200/gntp.167.4.393-414

Doebel, S. (2020). Rethinking executive function and its development. *Perspectives on Psychological Science*, *15*(4), 942–956. https://doi.org/10.1177/1745691620904771

Engel, G. L. (1977). The need for a new medical model: A challenge for biomedicine. *Science, 196*(4286), 129–136. https://doi.org/10.1126/science.847460

Eristi, B. & Avci, F. (2021). Preschool education teachers' evaluations about the problems experienced in the education process and their sources. *Psycho-Educational Research Reviews.* 10(3), 1–22. https://doi.org/10.52963/PERR_Biruni_V10.N3.01

Fay-Stammbach, T., Hawes, D. J., & Meredith, P. (2014). Parenting influences on executive function in early childhood: A review. *Child Development Perspectives, 8*(4), 258–264. https://doi.org/10.1111/cdep.12095

Fisher, A. V., Godwin, K. E., & Seltman, H. (2014). Visual environment, attention allocation, and learning in young children: When too much of a good thing may be bad. *Psychological Science, 25*(7), 1362–1370. https://journals.sagepub.com/doi/abs/10.1177/0956797614533801

Fisher, A., & Kloos, H. (2016). Development of selective sustained attention: The role of executive functions. In J. A. Griffin, P. McCardle, & L. S. Freund (Eds.), *Executive function in preschool-age children: Integrating measurement, neurodevelopment, and translational research* (pp. 215–237). American Psychological Association. https://doi.org/10.1037/14797-010

Fisher, A., Thiessen, E., Godwin, K., Kloos, H., & Dickerson, J. (2013). Assessing selective sustained attention in 3- to 5-year-old children: Evidence from a new paradigm. *Journal of Experimental Child Psychology, 114*(2), 275–294. https://doi.org/10.1016/j.jecp.2012.07.006

Foglia, L., & Wilson, R. A. (2013). Embodied cognition. *Wiley Interdisciplinary Reviews: Cognitive Science, 4*(3), 319–325. https://doi.org/10.1002/wcs.1226

Fugate, J. M. B., Macrine, S. L., & Cipriano, C. (2018). The role of embodied cognition for transforming learning. *International Journal of School & Educational Psychology, 7*(4), 274–288. https://doi.org/10.1080/21683603.2018.1443856

Fugate, J. M. B., & Wilson-Mendenhall, C. D. (2022). Embodied emotion, emotional granularity, and mindfulness: Improved learning in the classroom. In S. L. Macrine & J. M. B. Fugate (Eds.), *Movement Matters* (pp. 291–306). The MIT Press. https://doi.org/10.7551/mitpress/13593.003.0027

Gaekwad, J. S., Sal Moslehian, A., Roös, P. B., & Walker, A. (2022). A meta-analysis of emotional evidence for the biophilia hypothesis and implications for biophilic design. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.750245

Gallagher, S. (2023). *Embodied and enactive approaches to cognition*. Cambridge University Press.

Ghandour, R. M., Hirai, A. H., Moore, K. A., Paschall, K., LaForett, D. R., Reddington, E., & Kogan, M. D. (2024). School readiness among United States children: Results from the 2022 National Survey of Children's Health. *Academic Pediatrics, 24*(7), 1049–1061. https://doi.org/10.1016/j.acap.2024.02.013

Gifford, R. (2013). Environmental psychology matters. *Annual Review of Psychology, 65*(1), 541–579. https://doi.org/10.1146/annurev-psych-010213-115048

Godwin, K. E., Erickson, L. C., & Newman, R. S. (2018). Insights from crossing research silos on visual and auditory attention. *Current Directions in Psychological Science, 28*(1), 47–52. https://doi.org/10.1177/0963721418807725

Godwin, K., & Fisher, A. (2011). Allocation of attention in classroom environments: Consequences for learning. *Proceedings of the Annual Meeting of the Cognitive Science Society, 33*. https://escholarship.org/uc/item/15c4w7zg

Godwin, K. E., Leroux, A. J., Scupelli, P., & Fisher, A. V. (2022). Classroom design and children's attention allocation: Beyond the laboratory and into the classroom. *Mind, Brain, and Education, 16*(3), 239–251. https://doi.org/10.1111/mbe.12319

Godwin, K. E., Seltman, H., Almeda, M., Davis Skerbetz, M., Kai, S., Baker, R. S., & Fisher, A. V. (2021). The elusive relationship between time on-task and learning: Not simply an issue of measurement. *Educational Psychology, 41*(4), 502–519. https://doi.org/10.1080/01443410.2021.1894324

Guo, D., McTigue, E. M., Matthews, S. D., & Zimmer, W. (2020). The impact of visual displays on learning across the disciplines: A systematic review. *Educational Psychology Review, 32*(3), 627–656. https://doi.org/10.1007/s10648-020-09523-3

Haines, A. (2017). Strategies to support concentration. *NAMTA Journal, 42*(2), 45–60. https://eric.ed.gov/?id=EJ1144489

Hanley, M., Khairat, M., Taylor, K., Wilson, R., Cole-Fletcher, R., & Riby, D. (2017). Classroom displays—Attraction or distraction? Evidence of impact on attention and learning from children with and without autism. *Developmental Psychology, 53*(7), 1265–1275. https://doi.org/10.1037/dev0000271

Hanushek, E. A. (2005). Our school performance matters. *Journal of Education, 185*(3), 1–6. https://doi.org/10.1177/002205740518500303

Henderson, J. M., & Ferreira, F. (2004). *The interface of language, vision, and action: Eye movements and the visual world*. Psychology Press.

Immordino-Yang, M. H. (2015). *Emotions, learning, and the brain: Exploring the educational implications of affective neuroscience*. W.W. Norton & Company.

Immordino-Yang, M. H., & Gotlieb, R. (2017). Embodied brains, social minds, cultural meaning: Integrating neuroscientific and educational research on social-affective development. *American Educational Research Journal, 54*(1), 344S–367S. [Supplement]. https://doi.org/10.3102/0002831216669780

Irwin, V., Wang, K., Jung, J., Kessler, E., Tezil, T., Alhassani, S., Filbey, A., Dilig, R., & Bullock Mann, F. (2024). *Report on the condition of education 2024* (NCES 2024-144). U.S. Department of Education, National Center for Education Statistics. https://nces.ed.gov/pubs2024/2024144.pdf

Jeannin, L., & Barthelemy, S. (2020). Learning spaces and well-being: What is happening in France. *Journal of Learning Spaces, 9*(1). https://files.eric.ed.gov/fulltext/EJ1253901.pdf

Kaplan, R., & Kaplan, S. (1989). *The Experience of nature: A psychological perspective.* Cambridge University Press.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15*(3), 169–182. https://doi.org/10.1016/0272-4944(95)90001-2

Keller, A. S., Davidesco, I., & Tanner, K. D. (2020). Attention matters: How orchestrating attention may relate to classroom learning. *CBE—Life Sciences Education, 19*(3). [Special issue]. https://doi.org/10.1187/cbe.20-05-0106

Kilbourne, J. R., Scott-Webber, L., & Kapitula, L. R. (2017). An activity-permissible classroom: Impacts of an evidence-based design solution on student engagement and movement in an elementary school classroom. *Children, Youth and Environments, 27*(1), 112–134. https://doi.org/10.7721/chilyoutenvi.27.1.0112

Kosmas, P., Ioannou, A., & Zaphiris, P. (2018). Implementing embodied learning in the classroom: Effects on children's memory and language skills. *Educational Media International, 56*(1), 59–74. https://doi.org/10.1080/09523987.2018.1547948

Lillard, A. S. (2021). Montessori as an alternative early childhood education. *Early Child Development and Care, 191*(7-8), 1196–1206. https://doi.org/10.1080/03004430.2020.1832998

Lillard, A. S. (2023). Why the time is ripe for an education revolution. *Frontiers in Developmental Psychology, 1*, Article 1177576. https://doi.org/10.3389/fdpys.2023.1177576

Llorens-Gámez, M., Higuera-Trujillo, J. L., Omarrementeria, C. S., & Llinares, C. (2021). The impact of the design of learning spaces on attention and memory from a neuroarchitectural approach: A systematic review. *Frontiers of Architectural Research, 11*(3), 542–560. https://doi.org/10.1016/j.foar.2021.12.002

Lopez, R. T. (2020). *Creating meaningful classroom environments: How do teachers' pedagogical beliefs affect the implementation of their visual displays in elementary classrooms?* [Dissertation]. https://www.proquest.com/openview/e48a42f609394af5a8d232c99005321f/1?pq-origsite=gscholar&cbl=18750&diss=y

Lozada, M., & Carro, N. (2016). Embodied action improves cognition in children: Evidence from a study based on Piagetian conservation tasks. *Frontiers in Psychology, 7*(393). https://doi.org/10.3389/fpsyg.2016.00393

Lucente, M., & Guidi, J. (2023). Allostatic load in children and adolescents: A systematic review. *Psychotherapy and Psychosomatics, 92*(5), 295–303. https://doi.org/10.1159/000533424

Macedonia, M. (2019). Embodied learning: Why at school the mind needs the body. *Frontiers in Psychology, 10*. https://doi.org/10.3389/fpsyg.2019.02098

Mahone, E. M., & Schneider, H. E. (2012). Assessment of attention in preschoolers. *Neuropsychology Review, 22*, 361–383. https://doi.org/10.1007/s11065-012-9217-y

Mallory, C. & Keehn, B. (2021). Implications of sensory processing and attentional differences associated with autism in academic settings: An integrative review. *Frontiers in Psychiatry, 12*. https://doi.org/10.3389/fpsyt.2021.695825

Martin, R., & Wilkins, J. (2021). Creating visually appropriate classroom environments for students with autism spectrum disorder. *Intervention in School and Clinic, 57*(3), 176–181. https://doi.org/10.1177/10534512211014882

Mayer, R. E. (2005). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge*

handbook of multimedia learning (pp. 31–48). Cambridge University Press. https://doi.org/10.1017/CBO9780511816819.004

McDermott, K. B., & Roediger, H. L. (2018). *Memory (encoding, storage, retrieval)*. In R. Biswas-Diener & E. Diener (Eds.), Noba textbook series: Psychology. DEF Publishers. https://peachf.org/images/Science/MemEncodingStorageRetrievalMcDermott.pdf

Milo-Shussman, Y. (2017). "A little bit of this and not too much of that…": Is there a recipe for class display load level in elementary schools? *Journal of Learning Spaces*, *6*(2), 22–27. https://eric.ed.gov/?id=EJ1152575

Moll, A., Collado, S., Staats, H., & Corraliza, J. A. (2022). Restorative effects of exposure to nature on children and adolescents: A systematic review. *Journal of Environmental Psychology*, *84*, Article 101884. https://doi.org/10.1016/j.jenvp.2022.101884

Montessori, M. (1912). *The Montessori Method.* Heinemann.

Montessori, M. (1946). *Education for a new world*. Kalakshetra Publications.

Montessori, M. (1966). *Maria Montessori speaks to parents*. Schocken Books.

Montessori, M. (1979). *The child in the family*. Ballantine Books.

Navarro, J. L., & Tudge, J. R. H. (2023). Technologizing Bronfenbrenner: Neo-ecological theory. *Current Psychology*, *42*, 19338–19354. https://doi.org/10.1007/s12144-022-02738-3

Neuenschwander, R., Roebers, C. M., & Blair, C. (2014). Being optimally aroused matters: Effects of a weak stress manipulation on children's executive functions are moderated by temperament and age. *Journal of Educational and Developmental Psychology*, *4*(1). https://doi.org/10.5539/jedp.v4n1p194

Nusbaum, E. A., & Lester, J. N. (2021). Bodymind legibility and possibilities for qualitative research. In J. N. Lester & E. A. Nusbaum (Eds.), *Centering diverse bodyminds in critical qualitative inquiry* (pp. 10–21). Routledge. https://doi.org/10.4324/9781003033264-2

O'Connor, J. W., & O'Connor, C. B. (2024). *Elevating learning environments through biophilic and student-centered designs: A case study of Bethel-Hanberry Elementary School.* [Preprint]. https://cgdarch.com/wp-content/uploads/2024/04/BHE-Assessment_3.14.pdf

Pert, C. B. (1997). *Molecules of emotion.* Scribner.

Phillips-Silver, J., & Daza, M. T. (2018). Cognitive control at age 3: Evaluating executive functions in an equitable Montessori preschool. *Frontiers in Education*, *3*, Article 335663. https://doi.org/10.3389/feduc.2018.00106

Posner, M. I., & Rothbart, M. K. (2007). *Educating the human brain.* American Psychological Association. https://doi.org/10.1037/11519-000

Posner, M. I., & Rothbart, M. K. (2018). Temperament and brain networks of attention. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *373*(1744), Article 20170254. https://doi.org/10.1098/rstb.2017.0254

Price, M. (2014). The bodymind problem and the possibilities of pain. *Hypatia*, *30*(1), 268–284. https://doi.org/10.1111/hypa.12127

Randolph, J., Bryson, A., Menon, L., Henderson, D. K., Manuel, A. K., Michaels, S., Leigh, D., McPherson, W., O'Grady, R., & Lillard, A. S. (2023). Montessori education's impact on academic and nonacademic outcomes: A systematic review. *Campbell Systematic Reviews*, *19*(3), Article e1330. https://doi.org/10.1002/cl2.1330

Rimm-Kaufman, S. E., Pianta, R. C., & Cox, M. J. (2000). Teachers' judgments of problems in the transition to kindergarten. *Early Childhood Research Quarterly*, *15*(2), 147–166. https://doi.org/10.1016/s0885-2006(00)00049-1

Rodrigues, P. F. S., & Pandeirada, J. N. S. (2018). When visual stimulation of the surrounding environment affects children's cognitive performance. *Journal of Experimental Child Psychology*, *176*, 140–149. https://doi.org/10.1016/j.jecp.2018.07.014

Rothschild, B. (2000). *The body remembers: The psychophysiology of trauma and trauma treatment*. W. W. Norton & Company.

Sawyer, R. K. (Ed.) (2014). *The Cambridge handbook of the learning sciences*. Cambridge University Press.

Schenck, K. E., Walkington, C., and Nathan, M. J. (2022). Groups that move together, prove together: Collaborative gestures and gesture attitudes among teachers performing embodied geometry. In S. L. Macrine, & J. M. B. Fugate (Eds.), *Movement matters: how embodied cognition informs teaching and learning.* The MIT Press.

Schunk, D., Berger, E. M., Hermes, H., Winkel, K., & Fehr, E. (2022). Teaching self-regulation. *Nature Human Behaviour*, *6*, 1680–1690. https://doi.org/10.1038/s41562-022-01449-w

Shapiro, L., & Stolz, S. A. (2018). Embodied cognition and its significance for education. *Theory and*

Research in Education, *17*(1), 19–39. https://doi.org/10.1177/1477878518822149

Shepard, L. A. (1997). Children not ready to learn? The invalidity of school readiness testing. *Psychology in the Schools*, *34*(2), 85–97. https://doi.org/10.1002/(sici)1520-6807(199704)34:2%3C85::aid-pits2%3E3.0.co;2-r

Sleeman, H. R., & Brown, T. (2021). An exploratory study of the relationship between typically-developing school-age children's sensory processing and their activity participation. *British Journal of Occupational Therapy*, *85*(4), 251–261. https://doi.org/10.1177/03080226211020651

Students Speak. (n.d.). *Students speak about learning environment.* A collaboration of the Trauma and Learning Policy Initiative, Harvard Law School, and Massachusetts Advocates for Children. Retrieved November 8, 2025, from https://students-speak.org/priorities/environment/#classroom

Tang, Y. Y., Tang, R., Posner, M. I., & Gross, J. J. (2022). Effortless training of attention and self-control: Mechanisms and applications. *Trends in Cognitive Sciences*, *26*(7), 567–577. https://doi.org/10.1016/j.tics.2022.04.006

Tebano Ahlquist, E.-M. (2023). Learning in the Montessori school environment. In A. K. Murray, E.-M. Tebano Ahlquist, M. K. McKenna, & M. Debs (Eds.), *The Bloomsbury Handbook of Montessori Education* (pp. 117–128). Bloomsbury Academic. https://doi.org/10.5040/9781350275638.ch-12

Turoman, N., Tivadar, R. I., Retsa, C., Maillard, A. M., Scerif, G., & Matusz, P. J. (2021). The development of attentional control mechanisms in multisensory environments. *Developmental Cognitive Neuroscience*, *48*, Article 100930. https://doi.org/10.1016/j.dcn.2021.100930

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In I. Altman, & J. F. Wohlwill (Eds.), *Behavior and the Natural Environment*. Human Behavior and Environment (Vol. 6, pp. 85–125). Springer. https://doi.org/10.1007/978-1-4613-3539-9_4

Vella-Brodrick, D. A., & Gilowska, K. (2022). Effects of nature (greenspace) on cognitive functioning in school children and adolescents: A systematic review. *Educational Psychology Review*, *34*(3), 1217–1254. https://doi.org/10.1007/s10648-022-09658-5

Walker, N. (2021). *Neuroqueer heresies: Notes on the neurodiversity paradigm, autistic empowerment, and postnormal possibilities*. Autonomous Press.

William, D. (2010). Standardized testing and school accountability. *Educational Psychologist*, *45*(2), 107–122. https://doi.org/10.1080/00461521003703060

Willingham, D. T. (2015). Do students remember what they learn in school? Ask the cognitive scientist. *American Educator*, *39*(3), 33–38. https://eric.ed.gov/?id=EJ1076383

Willingham, D. T. (2021). *Why don't students like school? A cognitive scientist answers questions about how the mind works and what it means for the classroom*. Jossey-Bass.

Yang, B. Y., Zeng, X. W., Markevych, I., Bloom, M. S., Heinrich, J., Knibbs, L. D., Dharmage, S. C., Lin, S., Jalava, P., Guo, Y., Jalaludin, B., Morawska, L., Zhou, Y., Hu, L.W., Yu, H. Y., Yu, Y., & Dong, G. H. (2019). Association between greenness surrounding schools and kindergartens and attention-deficit/hyperactivity disorder in children in China. *JAMA Network Open*, *2*(12), Article e1917862. https://doi.org/10.1001/jamanetworkopen.2019.17862

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology*, *18*(5), 459–482. https://doi.org/10.1002/cne.920180503

Zazzi, H., & Faragher, R. (2018). 'Visual clutter' in the classroom: Voices of students with autism spectrum disorder. *International Journal of Developmental Disabilities*, *64*(3), 212–224. https://doi.org/10.1080/20473869.2018.1468619

Rediscovering the Child: Review of Montessori Educator Research Projects 2024–2025

Angela K. Murray, University of Kansas

This article is part of the *Journal of Montessori Research*'s annual series titled "Rediscovering the Child," which is an effort to disseminate practitioner research and classroom-based action research (CBAR) that does not typically have a widely accessible forum. CBAR is powerful because it is conducted in real classrooms with real children by practitioners who wish to address their real-world problems. Several studies are highlighted each year to inspire other practitioners to formalize their classroom inquiries for sharing with the wider community. Practitioners in the field can reflect on their own practice by learning how other educators address challenges they face.

Montessori (1909/1912) believed the teacher is an integral part of the scientific process, saying, "… if we make of the teacher an observer, familiar with the experimental methods, then we must make it possible for her to observe and to experiment in the school" (p. 28). In this spirit, Montessori teacher preparation programs often include requirements for CBAR or practitioner inquiry for trainees to receive credentials. The research featured here represents work from two such Montessori teacher preparation programs: St. Catherine University in Saint Paul, Minnesota, and University of Wisconsin–River Falls. Faculty selected from their programs six high-quality papers, which are discussed here.

Previous articles in this series included CBAR and practitioner inquiry studies, and that is also the case this year. Practitioner inquiry is similar to CBAR as both are conducted by educators investigating issues related to their personal teaching practices. The key difference is that practitioner inquiry, unlike CBAR, does not take place in the classroom (Gerker, 2024).

This review begins with studies that focus on life skills, by exploring the impact of outdoor play and engagement with nature on classroom engagement and focus. This topic is addressed separately by two different authors featured in this review: Speakmanova and Lederer. Work by Dinkler looks at the role of music in the development of prosocial behavior as a life skill. Next, papers addressing the academic subjects of reading and math are examined. The first of the academic-focused papers is by Allred and Johnson, who explore reading development for early childhood students who did not have 3-year-old Montessori experiences. In the second, Thompson investigates use of goal-setting strategies on math fluency for elementary students. This year's review concludes with a practitioner inquiry paper by Sadrnafisi,

who develops a supportive teacher community to address the causes of teacher turnover.

Life Skills

Three of the reviewed CBAR studies examined interventions in classrooms designed to enhance children's life skills through increased engagement, focus, or prosocial behaviors.

Speakmanova, H. (2024). ***Outdoor play and classroom engagement*** [Master's thesis, St. Catherine University]. https://cdm17519.contentdm.oclc.org/digital/collection/maed/id/609/rec/1

Speakmanova investigated the impact of outdoor free play on classroom engagement within the 3- to 6-year-old classroom. The intervention allowed children to play for about 30 minutes, two mornings each week, at a creek trail and small beach near the school. Classroom engagement was defined as interacting with peers, teachers, or objects in a developmentally appropriate manner; disruptive or destructive behaviors in the classroom were marked as unengaged. Over the course of six weeks, a slight increase in engagement was measured through classroom observation, tally sheets, and surveys. Additional findings from this CBAR study highlight the importance of movement, a balanced sensory input, and the role of the adult in early childhood development. In particular, interesting findings are related to the negative impact of overt adult direction and guidance.

Lederer, M. (2025). ***Time in nature and its impact on classroom focus*** [Master's thesis, University of Wisconsin–River Falls]. http://digital.library.wisc.edu/1793/95657

Similar to Speakmanova in her CBAR study, Lederer examined the effects of spending time outdoors but with Upper Elementary students. This practitioner's public Montessori charter school is located next to a large county park and woods, which provides a convenient and meaningful means to examine impact of outdoor time for 9- to12-year-olds. The study included six weeks of nature outings on Fridays, and the author collected data on productivity throughout those weeks. Data was also gathered about nature exposure at home. For measuring focus, the author used an instrument of the *Montessori Assessment Playbook* from the National Center for Montessori in the Public Sector (2019): "Observing Work Engagement–Elementary." Results demonstrated students staying focused for longer periods of time on nature outing days and seemingly less drastic productivity slumps usually seen on the last day of the school week. The practitioner-researcher deemed the most interesting findings were the unanticipated effects beyond the impact on student focus. The surveys showed strong support for spending school time in nature, with parents and students both feeling children are happier, more focused, calmer, and healthier after spending time in nature.

Dinkler, C. (2024). ***Joint music making in a Montessori classroom: Is there a correlation between joint music making and prosocial experiences?*** [Master's thesis, University of Wisconsin–River Falls]. http://digital.library.wisc.edu/1793/85537

Rather than outdoor play, Dinkler explored the potential of music-making to enhance life skills by fostering prosocial experiences. The author used a single student CBAR case study design in a Montessori family home care facility. Specifically, the intervention integrated joint music-making experiences into the morning work time in a small, private 3- to 6-year old classroom. The intervention added 15 to 20 minutes of joint music-making sessions each morning for two weeks, followed by one week without the intervention, alternating for three cycles over the course of more than nine weeks of the study. This single case study focused on the impact of the intervention on the prosocial behaviors of a 4-year-old who had challenges in this area. Data was collected through observations from the teacher, as well as from parents immediately after picking up the child from school. Results found an increase in positive social and emotional behaviors throughout the nine-week study period. This study further highlights the Montessori guide's ability to be flexible in following the child to adapt the classroom to meet their individual needs.

Academics

Two CBAR studies reviewed in this article focus specifically on enhancing academic skills, including reading and math skills.

Thompson, S. (2024). ***Reading development in a Montessori pre-K and kindergarten classroom*** [Master's thesis, University of Wisconsin–River Falls]. http://digital.library.wisc.edu/1793/85540

Thompson's CBAR study was conducted in a public Montessori charter classroom with 4-year-olds and kindergarteners. Thompson developed a structured literacy program using (1) the Montessori Method's

Movable Alphabet with the Waseca Reading Program towers (Waseca Biomes, 2021); (2) words, phrases, and sentences from *Primary Phonics* books (Makar, 2008); and (3) specific literary sequences embedded in the *Primary Phonics* series. The teacher-researcher found that ongoing literacy games and culture in her classroom contributed to students' overall growth and development. Other data, including parent surveys, indicate a structured approach to literacy is crucial. In particular, using the Movable Alphabet with image cards for spelling variations (encoding) prior to decoding from a book proved to be extremely effective. This study highlights some needs of a Montessori public setting where students who enter have missed the 3-year-old year of Children's House, which lays the foundation for literacy.

Allred, K. & Johnson, K. (2025). ***The impact of Montessori strategies and goal setting on math fact fluency with elementary students*** [Master's thesis, St. Catherine University]. https://cdm17519.contentdm.oclc.org/digital/collection/maed/id/612/rec/2

Over the course of six weeks, Allred and Johnson's CBAR study investigated the impact of an intervention incorporating Montessori lessons and goal-setting strategies on math fact fluency for 74 students in first through sixth grades. Students attended Montessori schools: a private school in Ohio and a public school in Georgia. Montessori lessons with didactic materials, along with goal setting, self-graphing of results, and student journals, resulted in increased positive feelings and dispositions, including motivation and confidence, toward math fact fluency. In addition, data from pre- and post-assessments of students' recall of math facts and computation showed improved accuracy and speed.

Practitioner Inquiry

The final graduate paper reviewed in this article is an example of practitioner inquiry because, although it was by a practitioner addressing challenges in her own setting, it was not conducted in her classroom.

Sadrnafisi, M. (2024). ***Investigating the causes of teacher turnover and cultivating a supportive teacher community to address the issue*** [Master's thesis, St. Catherine University]. https://cdm17519.contentdm.oclc.org/digital/collection/maed/id/603/rec/1

Sadrnafisi sought to improve teacher retention by building a community of trust, communication, and collaboration in a practitioner inquiry study. Over the course of eight weeks, five teachers who worked with ages 3 to 6 in a private Montessori school in Georgia engaged in one-on-one meetings every other week to connect with school leadership. This study also explored issues that initially motivated teachers to participate in the project, which brought to light teachers' daily challenges, such as issues with communication among colleagues and difficulties in managing student behaviors. Results highlight that improving communication between teachers and leadership enhances teacher satisfaction and feelings of being valued and heard through a process of resolving conflicts with colleagues or receiving essential support for challenges in the classroom.

Conclusion

The next installment in this "Rediscovering the Child" series is scheduled for fall 2026. For those who wish to explore other CBAR and practitioner inquiry papers, the American Montessori Society (AMS) Research Library (https://amshq.org/research-library/) has a repository available. AMS reports that Research Library updates are currently underway and commits to expanding the library. The organization also plans to establish in the future a new process for practitioners to submit practitioner inquiry and CBAR papers for consideration. The *Journal of Montessori Research* welcomes submissions of well-designed and thoroughly documented CBAR and practitioner inquiry studies to be considered for publication as individual articles (https://journals.ku.edu/jmr/about/submissions).

References

Makar, B. W. (2008). *Primary phonics set 1*. Educators Publishing Service.

Montessori, M. (1912). *The Montessori Method: Scientific pedagogy as applied to child education in "The Children's Houses"* (2nd ed) (A. E. George, Trans.). Frederick A. Stokes Company. (Original work published 1909).

National Center for Montessori in the Public Sector. (2019). *Montessori assessment playbook*. National Center for Montessori in the Public Sector Press.

Waseca Biomes. (2021). *Waseca reading program* [Educational material]. https://wasecabiomes.org/products/waseca-reading-program