MONTESSORI: EVIDENCE BASED READING CURRICULA

A Review of Data

ABSTRACT

Montessori instructional approach closely aligns with The Science of Reading. Standardized test scores and student background data from statewide data sets were reviewed to produce empirical evidence that students instructed in reading in schools using Montessori methods and curriculum achieve results significantly higher than the state average and expected results. These methods and the outcomes of this study exceed state and federal requirements of evidence.

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Publication Date: 4/17/2024

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Executive Summary

Background

The "Move on When Reading" (MOWR) policy adopted in Arizona and carried out by the Arizona Department of Education (ADE) and the Arizona State Board of Education (SBE) includes a requirement that schools offer evidence-based reading instruction for students from kindergarten through third grade. The evidence from this research demonstrates that the Montessori method of reading instruction effectively teaches children to read.

This whitepaper provides evidence that Montessori methods meet the requirements of a core reading instruction program and that it should be approved by ADE as a vetted core program that meets MOWR requirements. In this report, we review the empirical reading and language arts results of a group of Arizona Montessori schools and provide evidence of Montessori practices and material impacts on student reading achievement. This study was conducted by **independent researchers** including:

- Kelly Powell, Vice President and Director of Research at the Arizona Charter School Association
- Katie Brown, Ph.D., Director of Research and Professional Learning at the National Center for Montessori in the Public Sector
- Leslie Woodford, Curriculum Coordinator at Khalsa Montessori School

Montessori aligns closely with the Science of Reading in many ways, including the five components of literacy standards required to meet ADE and Every Student Succeeds Act (ESSA) as outlined in *Move on When Reading K-3 Core Reading Program Guidance* (ADE, n.d.):

1. Phonemic Awareness
2. Phonics
3. Vocabulary
4. Reading Fluency and Oral Reading
5. Reading Comprehension

Hollis Scarborough imagined reading as the intertwining of multiple strands of knowledge and skills divided into two categories: Language Comprehension—including all of the background knowledge to understand written word—and Word Recognition—all of the skills needed to interpret written language, as shown in Figure 1 on page 8. Scarborough's "Reading Rope" has become synonymous with "The Science of Reading." The first section of this report provides examples of materials and activities in the Montessori classroom that support each of these areas of literacy and shows how the Montessori Method is a comprehensive approach to skilled reading. The second section reviews statewide testing data to demonstrate that Montessori-educated students meet and exceed the state standards for literacy by third grade.

Research Design

In this report, we compare the reading performance of students in Arizona's public Montessori schools, the majority of which are charter schools, to that of the state as a whole. The research design includes a review of student-level enrollment and demographic data, as well as state test data results (AzMERIT/AZM2 English Language Arts, an **established measure**) from 2016 through 2019 with a **sample size** of 4,781 K-8th grade students across 26 different Arizona schools. The results are disaggregated by the number of Full Academic Years (FAY) students spent in the Montessori program, allowing us to demonstrate the impact of dosage on reading achievement. Standardized test results throughout this study are largely presented in two formats: percent proficient, and standardized scale scores, or z-scores, which represent the number of standard deviations from the state average.

Results

Year after year, Arizona's public Montessori schools perform well on the AzMERIT state test, and a few are among the highest performers in the state. Across all grade levels, the median ELA pass rate in Montessori schools was 77 percent compared to 46 percent in all non-treatment schools.

State test scores were standardized within content area and grade level, so the mean z-score for an Arizona grade level is 0.0 with a standard deviation of 1.0. From the data analyzed here, it is apparent that Montessori schools, on average across tested grades, scored 0.46 standard deviations higher than the non-treatment group. This would indicate a fairly substantial, or "moderate" **effect size** for the treatment and is highly significant (p <0.0001) given the t-test results. Montessori instruction in reading and writing, as measured by Arizona's state test, proved to be significantly higher than state averages and showed moderate effect sizes in all grade, demographic and student program groupings.

Furthermore, the comparison of treatment and non-treatment group standardized ELA scores by FAY and grade level showed that students achieve at higher levels the longer they remain in the treatment setting. Though one or two full academic years in the Montessori setting are significantly impactful on student performance, with good effect sizes 24 in both, students that remain in a Montessori setting for three or more years benefit the most (0.57).

Finally, controlling for demographic and programmatic differences between the Montessori treatment group and the statewide Arizona comparison group in a regression model, the treatment group observed scores were significantly higher than what would be predicted for them given the make-up of the student body.

Conclusion

This analysis demonstrates that Montessori is an evidence-based method of literacy instruction that produces positive **outcomes** for children. This review of data meets the **ESSA Tier 2** of moderate evidence.

Background

Arizona has several laws regarding literacy instruction in public schools[1]. The Arizona Department of Education (ADE) and the Arizona State Board for Education (SBE) are mandated to enforce the set of policies dubbed "Move on When Reading" (MOWR) that encapsulates the requirements of these laws. The policy received its MOWR nickname because one component of the policy states that third graders who do not pass a minimum threshold on the Arizona Academic Standards Assessment (AASA) may not "move on" to fourth grade.

MOWR stipulates that schools offer evidence-based reading instruction for students in grades K-3. Arizona public schools must use an Arizona Department of Education vetted core reading program to be compliant. For any proposed reading program, specific requirements must be met and evidenced by a research study. These requirements must meet the ADE and Every Student Succeeds Act (ESSA) five components of literacy standards as documented in *Move On When Reading K-3 Core Reading Program Guidance.* (ADE, n.d.)

1. **Phonemic Awareness**: The ability to identify and manipulate individual sounds (phonemes) in spoken words. Instruction focused on the awareness that the spoken sounds of language work together to make words.
2. **Phonics**: An understanding that there is a predictable relationship between phonemes and graphemes (sounds and letters).
3. **Vocabulary**: Development of word meanings and pronunciation necessary for communication. Includes listening vocabulary, speaking vocabulary, reading vocabulary, and writing vocabulary.
4. **Reading Fluency and Oral Reading**: Ability to read text accurately and at an appropriate rate. It provides the bridge between word recognition and comprehension.
5. **Reading Comprehension**: Purposeful steps used by active readers to make sense of text. Skills used for understanding, remembering, and communicating with others what has been read.

Objective

The public school Montessori community in Arizona seeks to have the Montessori method of reading and literacy instruction approved by the Arizona Department of Education as a vetted core program that meets the MOWR requirements.

The goal of this study is to review the empirical reading and language arts results of a group of Montessori schools and to provide evidence of Montessori practices and material impacts on student reading achievement.

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[1] A.R.S §15-701, A.R.S §15-704, and A.R.S §15-211 (as amended by HB2026)

Independent Researchers

The lead researcher in this study is Kelly Powell. He is a Vice President and Director of Research at the Arizona Charter School Association in Phoenix, Arizona, serving the research needs of 570 charter schools and often the larger public education community in the state. Earlier in his career, he served as Director of Testing for Arizona, managing state test programs including the first statewide use of inclusive test practices for students with disabilities and English learners, and managed Arizona's first generation of school report cards. At the National level, he served as State NAEP Coordinator and served as chairman of the National Education Statistics Agenda Committee for the National Center for Education Statistics (NCES). Besides working at the state and national levels, Kelly has worked at the district and school levels and in the private sector with a number of testing and education technology companies. He is not affiliated with Montessori education.

Other collaborators on the project include Katie Brown, who is the Director of Research & Professional Learning for the National Center for Montessori in the Public Sector. She is an advocate for Montessori education but is not a vendor of Montessori materials or curriculum. She holds a PhD in urban education from the University of North Carolina at Charlotte, where she studied outcomes for African American students in public Montessori schools. She is an adjunct faculty member at Whitworth University, where she teaches the Montessori Surround arc of graduate-level courses, and an affiliated researcher at the University of Kansas Center for Learner Agency Research and Action.

Leslie Woodford is an administrator at Khalsa Montessori School in Tucson where she serves in roles of Curriculum Coordinator and District Testing Coordinator. She holds Montessori credentials in Elementary I & II and administrator, as well as a master's degree in curriculum and instruction. She is an American Montessori Society Emerging Leaders Fellow. She is an advocate for Montessori education, but is not a vendor of Montessori materials or curriculum.

The Request for a Research Study

For the Montessori literacy and reading approach to be approved as a core reading instruction program through the ADE, a research study needed to be conducted to gather evidence of student reading achievement using this approach and curriculum. While the Montessori approach has been employed worldwide for more than a century, no research specific to the early grades of literacy and reading achievement has been published. Montessori educators provided the following research to ADE for review; however, these studies did not meet the specific criteria of ADE and ESSA for Montessori to be considered an approved Tier 1, 2 or 3 reading program. Therefore, a specific research study needed to be conducted.

Studies previously provided to ADE for review.

- 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), 252-266. This study of over 5,000 low-income Latinx children who attended pre-K in Miami-Dade

County compared third grade reading achievement for students who attended Montessori pre-K programs for one year to students who attended traditional pre-K programs. The Montessori group demonstrated better school readiness at the end of that one pre-K year, and went on to score higher on measures of reading learning at third grade.

- 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. This study compared state standardized reading test scores for 1,600 African American third grade students in Montessori and other magnet schools within the same region of a single urban district in North Carolina. Students from the Montessori schools scored significantly higher in reading their counterparts in the other magnet programs. These results indicate that African American students in public Montessori schools at grade three outperform their peers on traditional measures of academic achievement in reading. This is particularly remarkable given the lack of attention to testing and standardized test preparation characteristic of Montessori environments.

- Culclasure, B., Fleming, D.J., Riga, G., & Sprogis, A. (2018). *An Evaluation of Montessori Education in South Carolina's Public Schools*. The Riley Institute at Furman University. A study conducted by the Riley Institute at Furman, analyzed public Montessori programs in South Carolina from 2011 to 2016—the state with the most public Montessori schools. It found that, "When compared to non-Montessori public school students across the state, public Montessori students were more likely to have met or exceeded the state standards in each of the four subjects, [mathematics, English language arts, science, and social studies]." Further, children from low-income backgrounds enrolled in public Montessori schools in South Carolina outperformed their peers in reading, and improved more than demographically similar non-Montessori students.

- 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. This literature review summarizes the research on academic achievement for students of color in Montessori. The vast majority of studies reviewed find positive outcomes in reading for these students.

- Fraumeni-McBride, J. P. (2017). The effects of choice on reading engagement and comprehension for second-and third-grade students: An action research report. *Journal of Montessori Research*, *3*(2), 19-38.

- 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. In a longitudinal study of randomized lottery admissions to public Montessori PreK, Montessori students fared significantly better than waitlisted children on a host of academic and social-emotional measures, including assessments of early reading skills. Control children enrolled in a broad array of alternatives including magnet and private options. Importantly, children from low SES backgrounds reaped the most benefit from Montessori, and by kindergarten the typical

socio-economic opportunity gap was statistically insignificant in Montessori classrooms. Unfortunately, that gap had widened in traditional PreK over the 3-year study period.

- 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. The focus of this study is the academic achievement outcomes of Montessori public school students as compared to similar non-Montessori students. The Montessori students' reading scores in grades one through three were not statistically different than their non-Montessori counterparts. However, in grades four and five, the reading scores statistically favored Montessori students.

- Manner, J. C. (2007). Montessori vs. traditional education in the public sector: Seeking appropriate comparisons of academic achievement. *Forum on Public Policy, 2007*(2), 1-20. This study examines the relationship of public Montessori education, expressed as Stanford Achievement Test scores in reading, in comparison with similar scores for students in traditional programs, using a within-subjects, matched pairs design of repeated measures over a three-year period. Reading scores for the groups demonstrated significant differences, and in the second and third years of the study, Montessori students produced means which consistently outperformed the traditional group.

- Marshall, C. (2017). Montessori education: A review of the evidence base. npj *Science of Learning, 2(*1), 11. This study, while not an empirical evaluation of Montessori outcomes, reviews studies that pertain to the key elements of the Montessori method. The author finds that the key components of the Montessori approach to reading instruction are associated with positive outcomes in reading.

Additional Studies

- Fleming, D. J., & Culclasure, B. (2023). Exploring public Montessori education: Equity and achievement in South Carolina. *Journal of Research in Childhood Education*, 1-26. Through a comprehensive analysis of demographic characteristics and standardized test scores, these authors investigated the participation of different student groups in public Montessori programs and compared the academic achievement of public Montessori students to their peers in traditional public schools. Using matching procedures, the authors find that Montessori students demonstrated higher achievement growth in ELA and compared to similar traditional public school students. Subgroup analyses find that higher achievement growth for Montessori students is consistent across many student groups.

- L. Snyder, A., Tong, X., & Lillard, A. S. (2022). Standardized test proficiency in public Montessori schools. *Journal of School Choice*, *16*(1), 105-135. This study collected aggregated test score data from 195 Montessori schools in 10 states and compared each school to 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. Overall, and in all subgroups (Black, Hispanic, low-income) and at both test points (3rd and 8th grade), Montessori students were stronger

in English/Language Arts. Lastly, Black children in Montessori schools scored significantly higher than their peers in ELA.

Overview of the Montessori Method

Maria Montessori, founder and namesake for the pedagogy, materials, and methods underpinning a Montessori-based education, has been inspiring educators longer than the state of Arizona has existed. Montessori education spans the globe and is used in all continents that children inhabit in which organized schooling exists. Despite its reach, no formal study of the application of Montessori techniques and the role they play in student progress in the elements of the "Science of Reading" has been published.

In 2001, Hollis Scarborough visualized reading as a complex set of skills that intertwine to facilitate skilled reading. The skills of language comprehension—understanding language, how it works, and having background knowledge—must combine with the skills of word recognition including the ability to decode words and recognize irregular (sight) words in order for a person to learn to read. Figure 1 shows the many strands required.

In their book *Powerful Literacy in the Montessori Classroom: Aligning Reading Research and Practice,* authors Susan Zoll, Natasha Feinberg, and Laura Saylor detail how Montessori literacy instruction meets the components of the Science of Reading. The following overview relies on their work to build the framework for a non-Montessori educator to understand basic components of the Montessori approach.

Montessori and The Science of Reading

Montessori aligns closely with the Science of Reading in many ways, including the five components of literacy standards required to meet ADE and Every Student Succeeds Act (ESSA) as outlined in *Move on When Reading K-3 Core Reading Program Guidance* (ADE):

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Hollis Scarborough (2001) imagined reading as the intertwining of multiple strands of knowledge and skills divided into two categories: *Language Comprehension*—including all of the background knowledge to understand written word—and *Word Recognition*—all of the skills needed to interpret written language, as shown in Figure 1 on page 8. Scarborough's "Reading Rope" has become synonymous with "The Science of Reading."

Figure 1: Scarborough's Reading Rope. Image from "Really Great Reading."

The following sections provide examples of materials and activities in the Montessori classroom that support each of these areas of literacy and show how the Montessori Method is a comprehensive approach to skilled reading. Although, the Montessori approach does not contain a fixed set of components, the examples included here are common to most Montessori classrooms. As such, the Montessori methods and practices illustrated and referenced here comprise the core (Tier 1) reading program for students. Examples are provided for illustration purposes so that non-Montessorians can see how the Montessori method aligns closely with the Science of Reading. The second section of this article reviews statewide testing data to demonstrate that Montessori educated students meet and exceed the state standards for literacy by third grade. This paper demonstrates that Montessori is an evidence-based method of literacy instruction.

Phonemic Awareness

Phonemic awareness is the ability to identify and manipulate individual sounds (phonemes) in spoken words. Instruction focuses on the awareness that the spoken sounds of language work together to make words. Phonemic awareness is a component of phonological awareness, which is a term that describes all sound-related skills including recognizing words, syllables, rhymes, and individual speech sounds.

Montessori classrooms employ multiple materials to teach phonemic awareness including the I Spy Game, and object sound boxes.

I Spy Game

In the "I Spy Game" the teacher says to the class, "I spy with my little eye something in the room that begins with /p/." The children look around the room and call out objects that begin with that letter sound (paper, pencil, pushpin, etc.). If a child calls out a word that does not begin with the letter sound, the teacher uses it as a teaching moment. She says both words and initial sounds to invite the children to listen to the difference, perhaps even pointing out how her lips make a different shape for each sound. This activity is performed regularly in the classroom to help children learn to listen for the distinct sounds of the letters.

Object Sound Boxes

After practicing the I Spy game with the teacher, students move on to categorizing groups of miniature objects by their initial, middle or ending sounds. Figure 2 illustrates the rhyming words bat, hat, mouse, house, bee, and tree. When using this material, students say the words for each object aloud, listening for the objects that rhyme: house, mouse, for example, then group the objects in pairs at their workspace.

Figure 2: Object Box. Image courtesy of Leslie Woodford

Additional Materials and Activities Used

Students are taught songs with rhyming words like "Five Green and Speckled Frogs." They listen to books that focus on rhyme, for example *Sheep in a Jeep*, by Nancy Shaw.

These are three common activities in the Montessori classroom. There are a whole host of additional activities used including Elkonin boxes (sound boxes), and third-party curricula like Heggerty phonemic awareness are used. (Zoll et al., 2023)

Phonics

Phonics is an understanding that there is a predictable relationship between phonemes and graphemes (sounds and letters). In the Montessori classroom, phonics is taught through the use of multiple manipulative and sensorial materials.

Sandpaper Letters

The sandpaper letters are sandpaper letter shapes mounted on small boards, pink for consonants, and blue for vowels. The teacher instructs the students with the phonemic sounds of the letters. First, the teacher traces the sandpaper letter on the card, saying the sound of the letter, for example, "/m/" pause "/m/, this letter says the sound /m/. Look at my lips when I say /m/. Can you say /m/?" The child mimics the sound of the letter and traces the sandpaper letter, mimicking the teacher's hand movements. After the child feels confident with tracing the letter on the card, the teacher models drawing the letter in a sand tray; she models the sound of the letter and then writes it in the sand, as shown in Figure 3. The child practices writing the letter on her own. Teachers teach the letters of the alphabet systematically in groups of four to five letters.

Figure 3: Sandpaper letters and sand tray. Image courtesy of Leslie Woodford.

After students have learned the sounds of a group of letters, they begin to match small objects to the letters as shown in Figure 4. At first, they match the objects with their initial sounds; with practice they learn to sort objects by medial and final sounds as well.
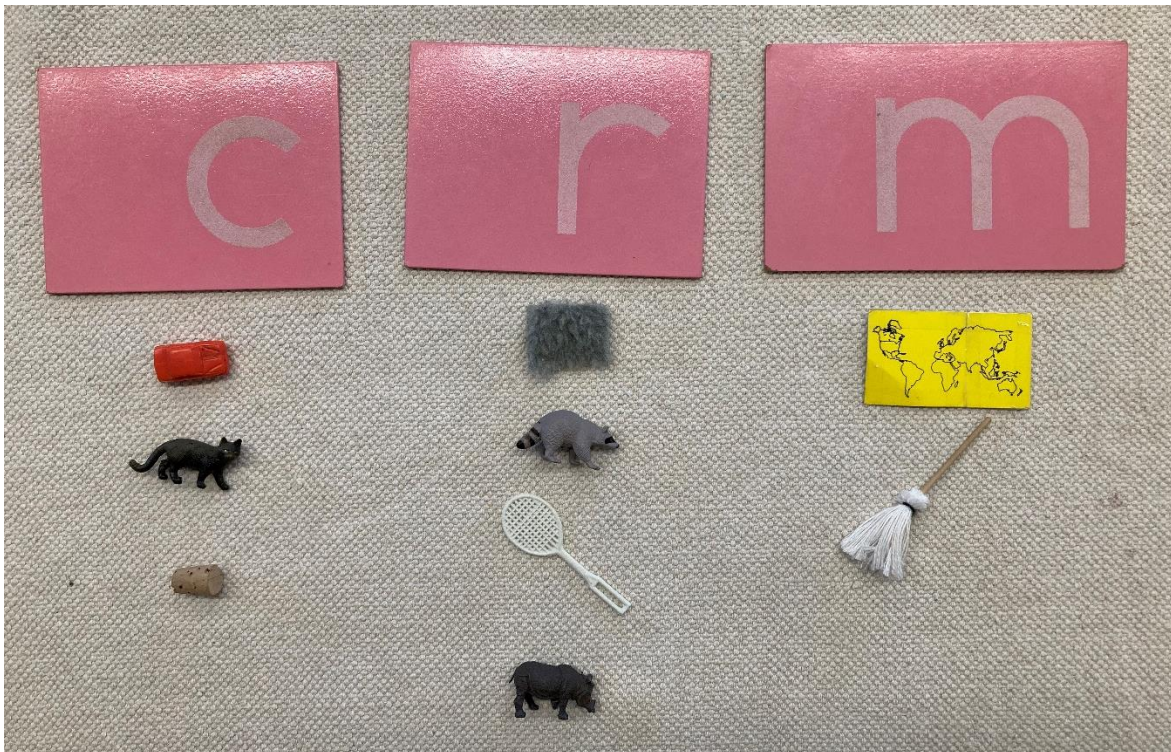

Figure 4: Sandpaper letters and first sound object matching. Image courtesy of Leslie Woodford.

Movable Alphabet

The movable alphabet consists of cutouts of wooden letters: red for consonants and blue for vowels. As students learn to recognize the letters of the alphabet, they use the movable alphabet. First, they match letters to initial sounds of objects. As they become adept with the medial and ending sounds of words, students begin to spell simple words with the movable alphabet, as shown in Figure 5.
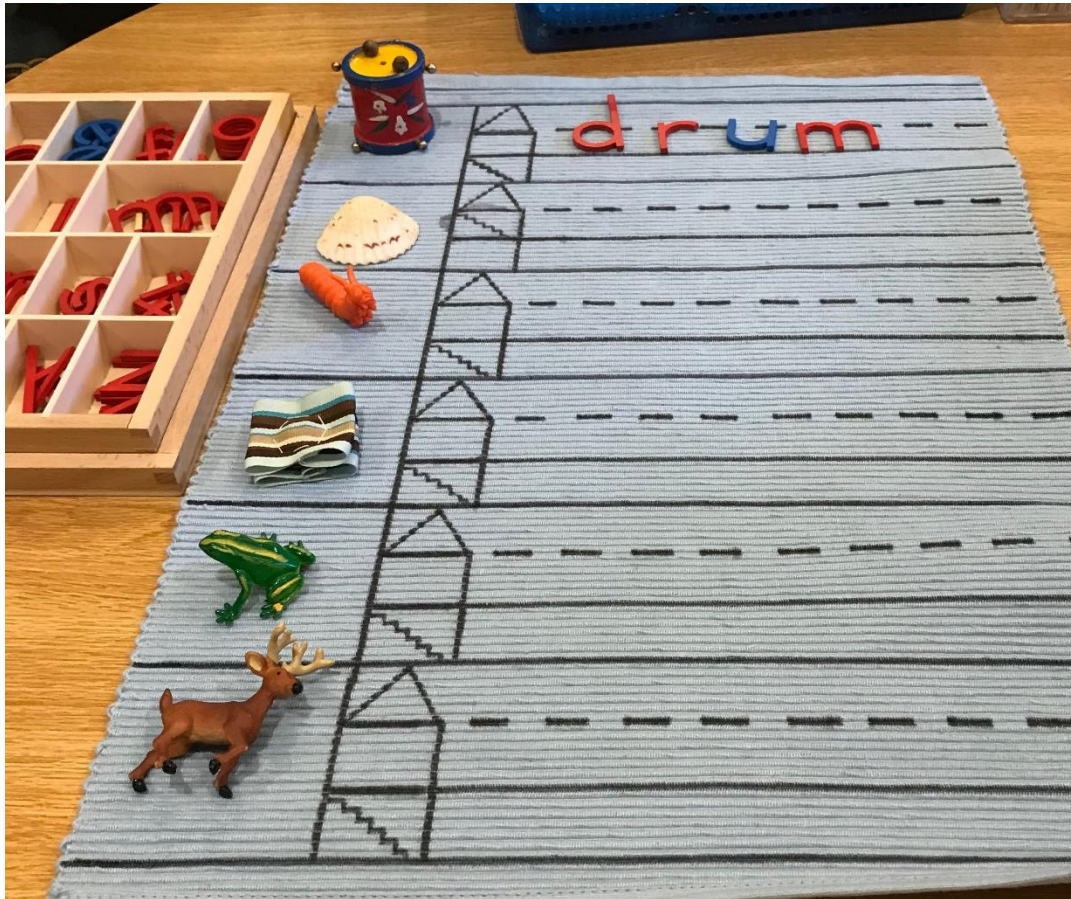
Figure 5: The Movable Alphabet gives children first lessons in writing. Image courtesy of Leslie Woodford.

Decodable Readers

As students increase their ability to create words with the movable alphabet, they transition from using objects to images. At this point, they are ready to use decodable readers. These short books contain simple words that systematically build phonics skills to support newly learned sounds. For example, the *Primary Phonics Storybook Sets* contain sets of 10 short books. The first book in the series focuses on the short /a/, with many words with the letter a in them. The second book focuses on the short /e/. Later books include words with silent "e" or the /sh/ sound.

Vocabulary

In order to become fluent readers, students must have sufficient vocabulary to understand the words that they are decoding on the page. The Montessori classroom is rich with vocabulary building materials.

Classification Cards

Classification cards are often referred to as "three-part cards." These cards build students' vocabulary skills. In the classroom, students progress from concrete representations of objects to images that represent objects. The cards allow students to expand their vocabulary. Students match an image and its corresponding word with a "control card" that contains the image and the word together on the card. Figure 6 shows three-part cards used to teach about different biomes. Topics range from zoology (for example, mammals) to botany (for example, parts of a tree) to land and water forms (bay, cape, gulf), to musical instruments. The possibilities are endless, and teachers often select (or create) card sets that support the interests of students currently in the classroom. For example, a set of cards showing various types of sharks might be used in the classroom of a child who is interested in marine life.

Figure 6: Classification cards to expand vocabulary. Image courtesy of Leslie Woodford.

Morphology

Morphology is the study of parts of words, for example, prefixes, suffixes, and root words. Students are introduced to the concepts of prefixes and suffixes first using objects and small cards. For example, in Figure 7, the root word is represented by the tractor. The root "drives" the meaning of the word, while the suffix is like the trailer. In the example, the root is "farm," and the suffix is "-er." The teacher explains that a suffix can't function alone, just like a trailer can't move without the tractor driving the word. In a similar way, prefixes are taught using physical objects.
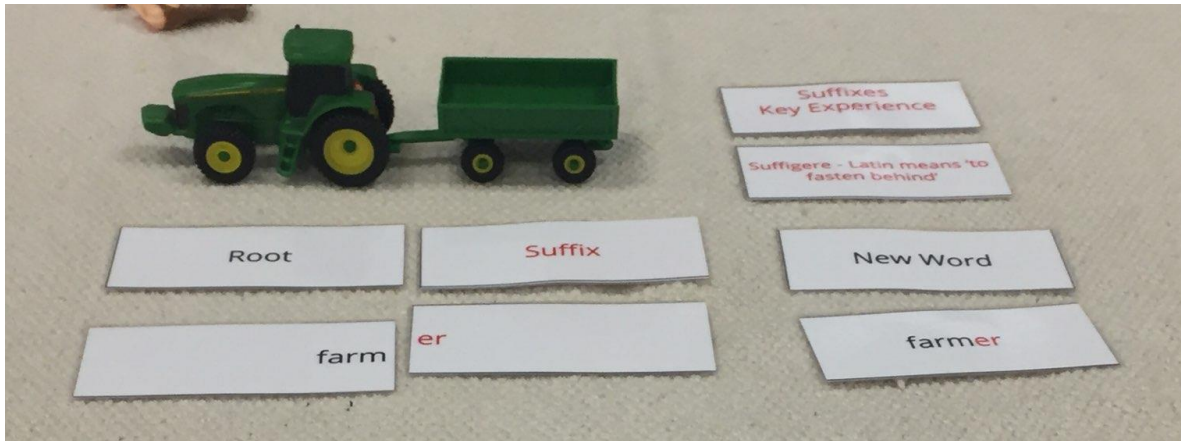
Figure 7: Objects represent the root and suffix of words. Image courtesy of Leslie Woodford

Word Study

Students practice the concept of suffix with matching cards as shown in Figure 8. The Montessori classroom is rich with movable materials such as this to expand students' vocabulary. The material pictured comes from the Word Study material published by Montessori Research and Development; it is commonly referred to as "The Skyscraper Towers." The Skycrapers which contains over 5,000 movable cards. The manipulative nature of the materials isolates the concept being taught. This is especially effective for students for whom handwriting would slow down the learning process.
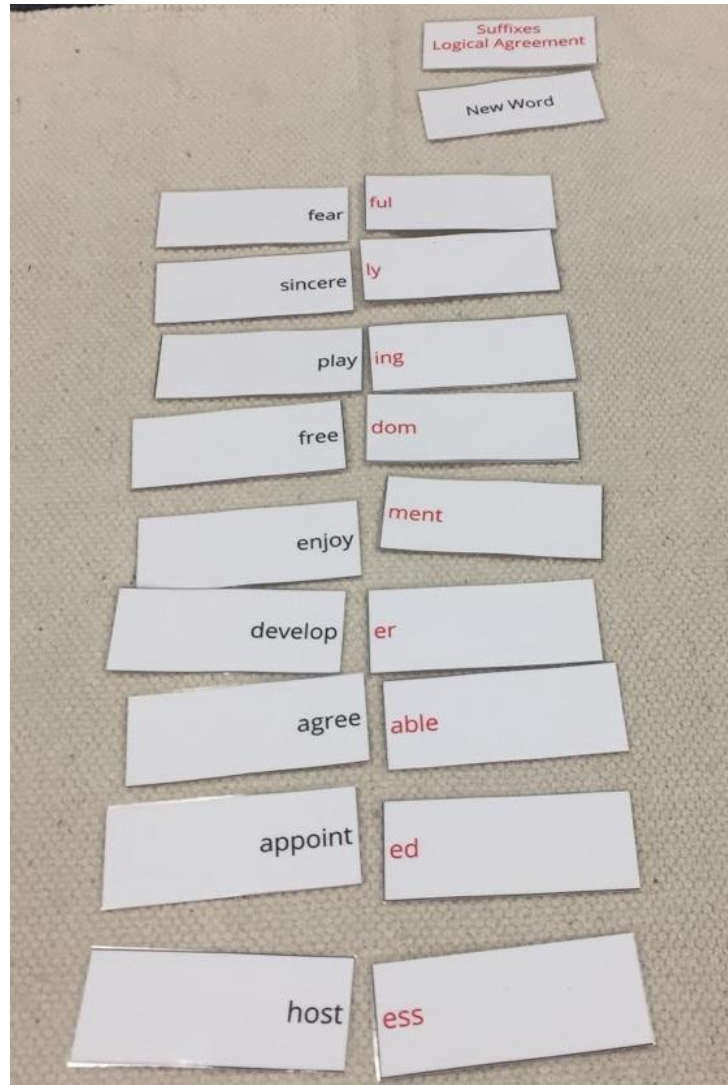
Figure 8: Suffix cards from the Skyscraper material.

Using the Skyscrapers, students expand their vocabulary through regular word study. This material includes synonyms, antonyms, homonyms, and compound words. This material also teaches concepts of mechanics: capitals, periods, apostrophes, commas, and quotations. The activities allow the child to practice classification, alphabetizing, the use of guide words for research, dictionary skill building and thesaurus usage. Whenever introducing new concepts the teacher uses an object lesson to explain the concept. For example, when introducing compound words, the teacher might display a safety pin and a wheel. Putting the two root words together forms the word "pinwheel." The teacher would then produce a pinwheel—which would have been kept hidden until the word was created as in Figure 9. The children are delighted with surprise when the newly crafted word and object are displayed. These story-based object lessons help make abstract concepts concrete.

Figure 9: Objects used to teach compound words. Image courtesy of Leslie Woodford.

Reading Fluency and Oral Reading

Reading fluency is the ability to read text accurately and at an appropriate rate. It provides the bridge between word recognition and comprehension. Fluent readers must be able to recognize words on sight without having to consciously decode the graphemes. In the Montessori classroom, children learn to write, using the movable alphabet before they learn to read. This process of physically moving the letters to create words builds strong connections in the brain and facilitates the process for students to learn to read.

To achieve reading fluency, children learn sight recognition through structured literacy activities. They learn sight words. The teacher follows proscribed patterns of instruction to teach consonant digraphs ("th," "sh," "tch," "dge"), blends ("scr," "st"), and silent letter combinations ("kn," "gn"), as well as vowel patterns (ae, oi, ar, ee).

Reading Comprehension

Reading comprehension includes purposeful steps used by active readers to make sense of text. For students to become strong readers, they must bring together the various strands on the Reading Rope, including background knowledge, vocabulary development, language structure and verbal reasoning. Vocabulary development has been covered above. An explanation of how Montessori builds background knowledge and teaches language structure follows.

Background Knowledge: Cultural Lessons

Working hand in hand with a rich vocabulary developed through Montessori literacy instruction, strong readers have sufficient background knowledge to understand what they read. History, geography, botany, and zoology are considered the "Cultural[2]" subjects in a Montessori classroom. As one Montessorian explained, "What leads children to want to read, [and] write, … is not reading, [and] writing, … taught in isolation, but the practical application of reading, [and] writing, … in areas in which the children are interested. Lessons in the cultural areas – science, history, geography, international studies, art, and music – best creates the passion to learn to read, write, and use mathematics." (Seldin, 2008)

One example of a complex Montessori material is the Timeline of Life (as shown in Figure 10) which introduces the history of the earth and all its life-forms. This material is nine feet long and includes movable images that students can place on the timeline. It is laid on the floor, and students work with it over a course of multiple weeks. From this work, students learn scientific terms like Cambrian Period and Cenozoic Era. They study dinosaurs and all forms of life, greatly enhancing their vocabularies.


Figure 10: The Montessori Timeline of Life. Image courtesy of Alison's Montessori.

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[2] Subjects other than math and language arts are dubbed "cultural subjects" in the Montessori classroom.

Language Structures

Language structures refer to the grammatical patterns of language. The study of grammar starts in the Montessori preschool classroom with the grammar symbols, as shown in Figure 11. Three dimensional objects represent various parts of speech. A black pyramid represents the noun. The teacher tells the story of the pyramid explaining that it is a fixed, concrete object that has endured thousands of years, and it represents the stable nature of a fixed object: a person, place or thing. When introducing verbs, the teacher uses a red ball and tells the story of the verb, showing how the ball can easily be put into motion the same way that a verb is a word that shows an action. Smaller pyramids represent articles and adjectives, while a smaller ball represents the adverb.
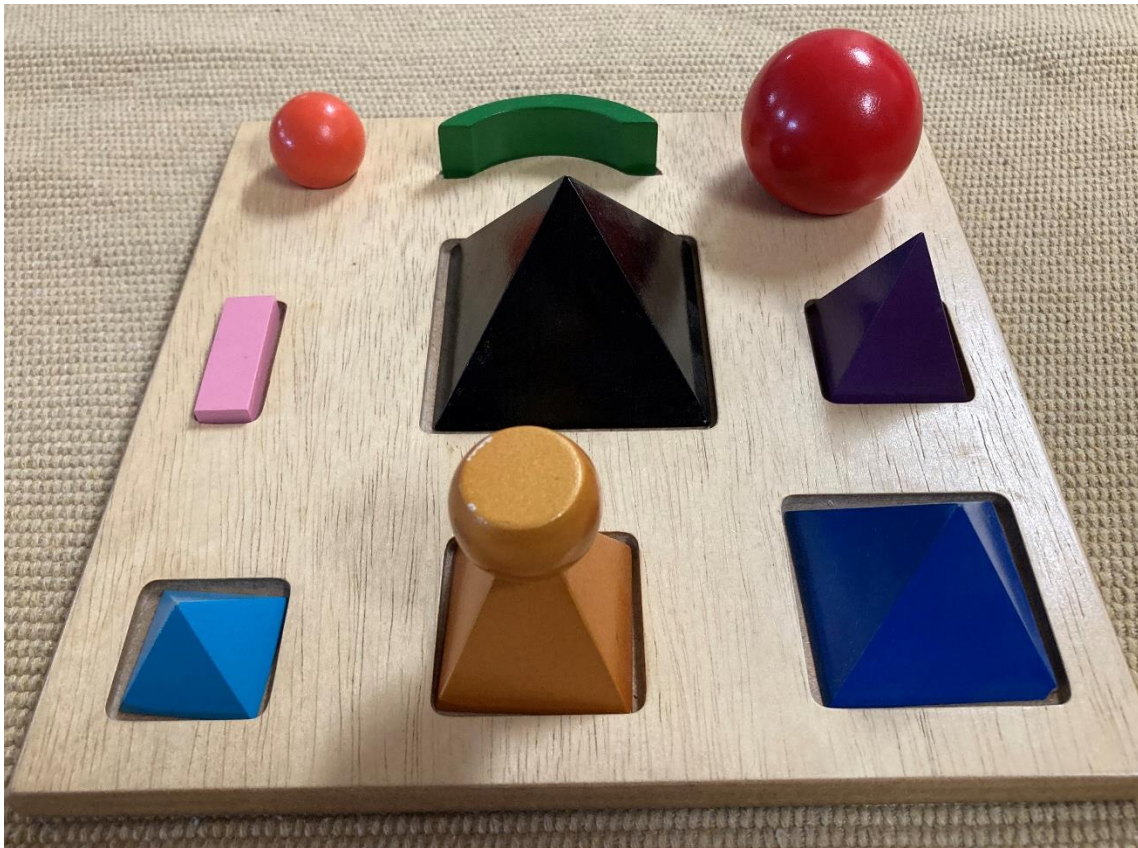
Figure 11: Montessori grammar symbols. Image courtesy of Leslie Woodford.

In the elementary classroom, children learn about pronouns, conjunctions, prepositions, articles, and adjectives. They are introduced to these concepts using the three-dimensional grammar symbols. Each has an associated story—the use of storytelling engages the children's interest and provides concrete associations to explain abstract concepts. Once they understand the concepts of the various parts of speech, they use two-dimensional paper cutouts to symbolize the parts of speech, and they parse sentences by placing the cutouts above the words of sentences.

Review of Data

A review of data was conducted using state standardized test data.

Research Design

The research design is a review of student-level enrollment and demographic data, as well as state test data (AzMERIT) results for SY2016-2019, for grades K-8 provided by the Arizona Department of Education through a restricted-use data sharing agreement and was analyzed for this project. Though all enrollment, program, attendance and test data were provided at the student level, no "student identifying information" (such as student name, local identification number, etc.) was available. Records were linked anonymously.

Specific data included enrollment and year-end code information, full-academic year or FAY information, student group information (race/ethnicity as well as program participation), school entity number, test data at the subtest level for ELA, as well as Mathematics. Due to the large amount of data over several years, and the relatively meager goals of this study, data analysis is largely limited to descriptive statistics, including trends over time.

Montessori programs that comprise the treatment group were identified by school mission statement and school name. More detail on the fidelity of the treatment group is provided elsewhere in this paper. A content review of Montessori curriculum, methods and practices aligned to Arizona content standards and MOWR requirements was completed well ahead of data analysis and aligns to the time period of focus, 2016-2019.

Standardized test results throughout this study are largely presented in two formats: percent proficient, and standardized scale scores. Standardized scores, i.e. z-scores, 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 from the state average. So, a score of 0.68 indicates the group is 0.68 standard deviations *above* the state average. A score of -0.13 is 0.13 standard deviations *below* the state average for that grade. When aggregated in group measures, these standardized scores mirror effect size estimates such as Cohen's d and serve as such throughout this paper.

Though multiple years of data were available, the majority of analyses were focused on data from the 2019 school year. The decision to do this was driven by pragmatism. The original plan was to map student attendance patterns back to the 2016 school year to breathe some history into limited state assessment results, thus extending grade three results to student participation back to kindergarten. With the availability of a three-year FAY measure, which allowed us to group students by the number of years in treatment/control group settings, the attendance tracking was already complete. Also, due to the dynamic nature of the public school sector in Arizona, focusing on the most recent school year data ensured the largest number of student subjects and avoided missing data and potential shifting treatment group dynamics.

The restricted-use, student-level data was combined to a comprehensive school database extracted from the National Center for Education Statistics online data warehouse of historical school level data.

Montessori Fidelity of Schools in the Data Set

Charter schools are tuition-free public schools of choice funded by state money but run independently. Most, public Montessori schools in Arizona are charter schools. Schools failing to provide contracted services according to the school charter are subject to sanction including closure by the state. The charter portion of the Montessori treatment group is reviewed on a regular basis by staff from the Arizona State Board for Charter Schools (ASBCS). Charter school regulatory performance frameworks include a review of academic, financial and operational data and occur, minimally, every five years. Charter reviews include a review of curriculum and consistency with the school's stated mission. In-person reviews by the Charter board can occur at any time and may or may not be announced prior to occurring. These regulatory reviews provide a system to ensure that schools claiming to employ the Montessori model and methods strive for a high level of fidelity.

In addition to the regulatory reviews, Montessori schools, by their nature, hold themselves accountable for maintaining Montessori fidelity. Unlike a purchased, self-contained curriculum, Montessori is a philosophy of education. Schools that elect to implement Montessori principles often do so because of a commitment to the ideals of the Montessori approach. As a result, they have a relatively high level of fidelity to the philosophy.

Given the composition of the sample, being primarily charter schools with consistent and detailed regulatory oversight, it is reasonable to assume that the results will reflect the impact of Montessori methods and materials.

ESSA Evidence Tier

The study has a number of hallmarks of a quasi-experimental design. This study seeks to determine if Montessori reading and ELA instruction is sufficient for students to progress towards and reach proficiency at least as well as other Science of Reading vetted curricula. Ample evidence exists and has been summarized to show that Montessori ELA instruction has content validity in accordance with all the strands of the Reading Rope. We also know from aggregate state test results that students in Montessori schools score above the state average in ELA. Yet to be determined, though, is whether students who have entered the Montessori setting were already proficient, or if exposure to Montessori methods and materials either sustain a high level of performance or increase student learning leading to higher performance levels on state test scores.

To determine the impact of Montessori instruction on students, state data records present the opportunity to do a quasi-experiment (ESSA Tier 2), using Arizona's full academic year (FAY) indicator as a treatment level variable for both the Montessori curriculum group and statewide comparison group. 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 control group in absolute terms, benefit challenging populations such as English learners and special education students, and increase student performance on state measures the longer students remain in the Montessori setting.

As you will see, the results contain statistically significant positive outcomes. There are no negative findings. The sample size of the treatment group is large (4,781 students), well over the established threshold of 350, and is comprised of the 24 different public Montessori schools from around the state of Arizona—the universe of school of that type at the time. Creating a matched comparison (or control) group based on demographics and/or geography would create results that are dependent on the matching methods and answer the question at the heart of the study: Are Montessori methods and materials sufficient in preparing students to read and write? Given the descriptive, group-comparative, and regression results, the answer is, "yes."

Established Measure

For the years studied, Arizona's Measurement of Educational Readiness to Inform Teaching (AzMERIT) was the statewide achievement test for Arizona students in Grades 3-8. All Arizona public school students in Grades 3-8 took the grade level AzMERIT assessments in English Language Arts and Mathematics. Although Arizona has changed test names several times in the past decade, the state utilizes a common item[3] bank and has maintained the measurement scale for more than a decade. The key measures for this study will be 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 have remained enrolled in an educational setting. FAY 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 that a student has been at the school for one full school year; FAY 2 indicates two years at the school, and FAY 3+ indicates that a student has been at the school for three years or more. Because there isn't a standardized statewide test that Arizona uses in first or second grade, it is hard to measure the effectiveness of early literacy programs. However, by reviewing the FAY data, it is possible to gain a glimpse of the effectiveness of literacy education in the three years preceding the state assessment using a quasi-experimental design.

Data for this Study

To ensure fidelity of the data sets obtained through restricted-use data license, a basic measure (student count by grade level) was compared to the extant October 1 "headcount" enrollment file provided in the 2019 school year (see figure below). Though there is a small difference in the grade level counts for each file, the magnitude was small, and the direction indicated more students were in Arizona by year-end compared to October 1. This direction of difference is not unexpected and typical of a growing state such as Arizona.

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[3] "Item" is a test makers' word for "problem" or "question." The questions on the state assessment are called "items."

Year End Enrollment compared to October Enrollment, 2019 SY

Legend: October Enrollment — 2019 Year End
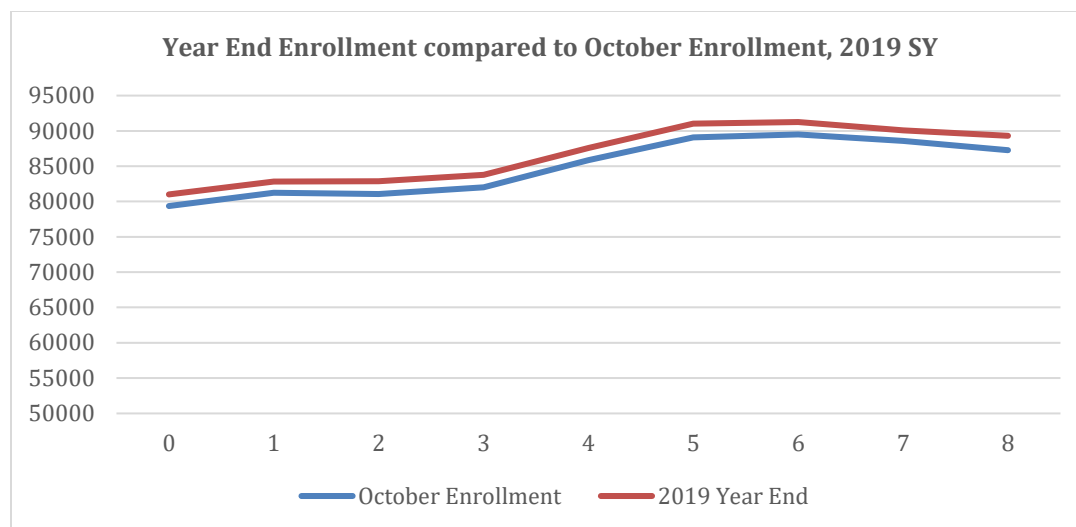
The group of Montessori schools included in the "Treatment Group" of this study comprise all, or virtually all, of the public Montessori schools in Arizona in the 2019 school year. Every effort was made to identify all schools that utilized Montessori methods, materials, and practices for the study group.

Montessori Schools in Treatment Group SY 2019
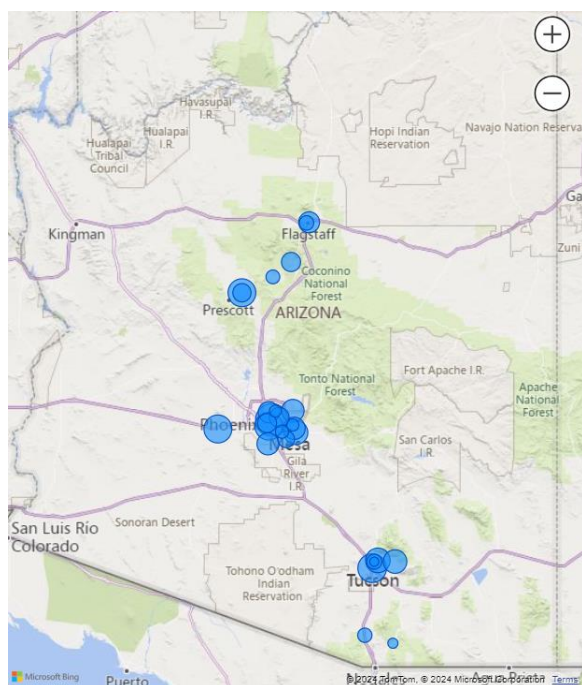
School Name	Student Count
ACORN MONTESSORI CHARTER SCHOOL	346
ACORN MONTESSORI CHARTER SCHOOL INC. - WEST	130
AUGUSTUS H. SHAW MONTESSORI	342
DRACHMAN PRIMARY MAGNET SCHOOL	371
HAVEN MONTESSORI CHARTER SCHOOL	72
HERMOSA MONTESSORI CHARTER	237
KEYSTONE MONTESSORI CHARTER SCHOOL	203
KHALSA MONTESSORI ELEMENTARY SCHOOL - PHOENIX	142
KHALSA SCHOOL	261
LEHI MONTESSORI	45
MEYER MONTESSORI	56
MISSION MONTESSORI ACADEMY	213
MISSION MONTESSORI ACADEMY'S MIDDLE YEARS PROGRAM	43
MONTESSORI ACADEMY	157
MONTESSORI CHARTER SCHOOL OF FLAGSTAFF - CAMPUS	179
MONTESSORI DAY PUBLIC SCHOOLS CHARTERED - MOUNTAINSIDE	181
MONTESSORI DAY PUBLIC SCHOOLS CHARTERED - TEMPE	105
MONTESSORI DE SANTA CRUZ - ST. ANN'S HALL	70
MONTESSORI EDUCATION CENTRE CHARTER SCHOOL - MESA	247
MONTESSORI EDUCATION CENTRE CHARTER SCHOOL - NORTH CAMPUS	207
MONTESSORI SCHOOLHOUSE	100
PAINTED DESERT MONTESSORI LLC	349
PATAGONIA MONTESSORI SCHOOL	27
SEDONA CHARTER SCHOOL	145
VERDE VALLEY MONTESSORI SCHOOL - A CENTER FOR CREATIVE EDUCA	64
VILLA MONTESSORI - PHOENIX CAMPUS	489
Total	**4781**

SOURCE: Common Core of Data, Arizona State Board for Charter School Records and archival research on school missions

Some basic demographics of the Treatment Group as well as Arizona as a whole, are provided below for comparison purposes for the grade levels studied. It should be noted that virtually all of the students in the treatment group are in their Montessori school by choice (even in the

district schools). "Schools of choice" do not have attendance boundaries, per se, and parents typically enroll and transport students to these schools because it is their choice. Though the Montessori schools roughly mirror the population of their surrounding LEAs, there are some differences between the treatment group and Arizona as a whole. Still, the treatment group is far from being homogeneous and represents students from all race/ethnic backgrounds.

In terms of special programs (English language development for English learners and Special Education for students with disabilities), Montessori schools in the sample had fewer English Learners, but a comparable percentage of Special Education students.

Group Percentages in Study (SY2019)		
	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 Learner	2%	6%
Free or Reduced Lunch Program	17%	44%
Special Education	12%	13%

STATE TEST RESULTS SUMMARY

Test results for the AzMERIT English Language Arts test are presented and discussed below in a variety of formats. Arizona's state test initially came from the multi-state PARCC test consortium though it has had a number of small changes in content and test blueprint formulation, the underlying "test scale" was maintained throughout its history. The test scores reflect student reading and writing performances, and are largely taken online, though state law requires a "paper and pencil" format of the test to be made available.

English Language Arts Scores for Montessori Schools and Arizona, 2019 School Year

Test Level	Montessori (Treatment)		Arizona (Control)		TOTAL	
	N	Median	N	Median	N	Median
3	591	78	80,768	46	81,359	46
4	496	74	84,804	50	85,300	50
5	502	82	88,265	52	88,767	52
6	405	75	88,248	42	88,653	42
7	299	75	86,757	40	87,056	40
8	242	71	84,693	38	84,935	38
TOTAL	2,535	76	513,535	46	516,070	46

Year after year, Arizona's public Montessori schools perform well on the AzMERIT state test, and a few are among the highest performers in the state. Median pass rates of the Montessori "Treatment" group were well above the rest of Arizona in all grade levels on the AzMERIT ELA exam in SY 2019, and all school years in our data set. Across all grade levels, the median pass

rate in Montessori schools was 76 percent compared to 46 percent in all non-treatment schools. It should be noted that schools with less than 11 students were redacted in the state file of released school data. Consequently, some student counts differ from the student-based analyses.

The tables below show mean standardized ELA scores for students in the treatment group (Montessori schools) and all schools not in the treatment group. Due to the decline in student numbers in the middle grades in the treatment group, grades 6 through 8 were combined in many tables and figures that follow. From casual observation, it appears the decline in enrollment in the middle grades is due to many schools serving only primary grades. Also, some attrition occurs in "choice" schools as students approach terminal grade levels in schools and "migrate" to other LEAs and settings to prepare for transition to high school. On a side note, there were no public Montessori high schools in Arizona in 2019.

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

Grade Level	Treatment (Montessori)			All Others (Arizona)			Significance Testing	
	N	score	sd	N	score	sd	t	p
3	605	0.48	1.03	80662	0.00	1.00	11.46	<0.0001
4	534	0.40	0.94	84529	0.00	1.00	9.83	<0.0001
5	519	0.46	0.91	88000	0.00	1.00	12.29	<0.0001
6 to 8	985	0.49	0.95	259425	0.01	1.00	18.12	<0.0001
TOTAL	2643	0.46	0.96	512616	0.01	1.00	26.52	<0.0001

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

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 of 1.0. From the scores shown above, it is apparent that Montessori schools, on average across tested grades, scored 0.46 standard deviations higher than the non-treatment group. This would indicate a "moderate" effect size for the treatment and is highly significant (p <0.0001) given the t-test results. Montessori instruction in reading and writing, as measured by Arizona's state test, resulted in significantly higher than state averages and showed moderate effect sizes in all grade groupings.

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. So a slightly higher state average of 0.01 was apparent for the 512,616 students comprising the "control group."

The Relevance of Full Academic Year Information in the Analysis

Full Academic Year (FAY) is a control variable central to the Arizona accountability formula for determining school quality. FAY is used widely in Arizona and elsewhere to ensure that the students that "count" in accountability measures actually participated meaningfully in a school setting for the state test results to serve as an indicator. Students who are not enrolled by the end of September, or who leave for significant time periods (or permanently) before the first day

of statewide spring testing are coded "0" and are "not FAY." How many years a student is enrolled and considered FAY is also captured in state data files, for 1 to 3+ years of enrollment. This data field is very useful when considering the impact of a curriculum and approach on outcome measures since FAY is a basic quantification of the degree the treatment has been employed. The 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 treatment setting. FAY is determined uniformly by the Department of Education and is available for review and correction by all schools in the state through the course of school accountability modeling. Suffice it to say, FAY is a measure that has been validated by schools to ensure its accuracy.

Proportion of Students Full Academic Year Status for the Montessori School Treatment Group and All Others in the 2019 School Year
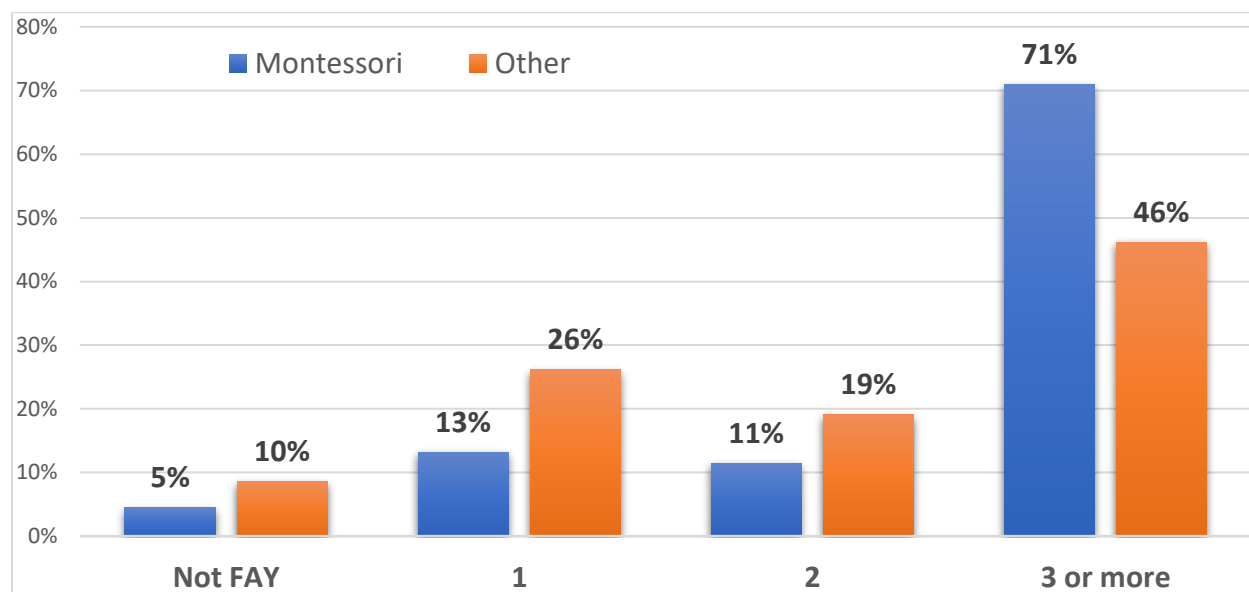
Compared to statewide FAY numbers, the Montessori school treatment group has a bit more stability (with a higher percentage in FAY 3+). This pattern is typical of schools populated completely through school choice. Parents make an initial change of schools, usually in the early primary grades, and stick with the school until the student matriculates to the secondary level, or "ages out" of a terminal grade level in a school.

Mean Standardized Scores for Treatment Group (Montessori) and Control (Other) FAY compared to non-FAY Performance in SY 2019

Averaged across grade levels, students present for the full academic year (FAY) fared better than their non-FAY counterparts on standardized state test scores for both the Montessori treatment group and statewide control group. Students receiving 1 or more full years of Montessori instruction and methods outperformed their control group peers. Indeed, the control group peers with FAY (0.04) performed on average roughly equivalent to non-FAY Montessori students (-0.01).

Comparing the non-FAY treatment group to the larger Arizona statewide context, there is <u>no significant difference</u> (p =0.92). Considering this group of students are new to Montessori schools but come from the general Arizona population this result is not surprising, but meaningful. Indeed, given the significant impact of Montessori curriculum on FAY students (p<0.0001) this leads to a provocative conclusion: students enter Montessori schools statistically indistinguishable from the Arizona average, but score significantly higher once they attend a Montessori school for at least one full academic year.

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

Attendance History	Treatment (Montessori)			Significance Testing	
	N	score	sd	t	p
Not FAY	115	-0.01	1.04	0.10	0.92
FAY	2528	0.49	0.95	25.93	<0.0001
TOTAL	2643	0.46	0.96	24.63	<0.0001

Montessori and Non-Montessori ("Other") ELA Performance by Grade and Full Academic Year (FAY), 2017-2019

SY2017

Treatment	0 (not FAY)	1	2	3 or more
Montessori	0.19	0.27	0.42	0.63
3	0.08	0.23	0.31	0.60
4	0.20	0.10	0.58	0.53
5	0.22	0.34	0.32	0.62
6-8	0.25	0.35	0.50	0.73
Other	-0.39	-0.05	0.03	0.11
3	-0.37	-0.09	0.01	0.10
4	-0.37	-0.12	0.00	0.11
5	-0.37	-0.06	-0.05	0.11
6-8	-0.42	-0.03	0.06	0.10
Total	-0.40	-0.05	0.03	0.11

SY2018

Treatment	0 (not FAY)	1	2	3 or more
Montessori	0.31	0.21	0.26	0.58
3	-0.12	0.29	0.25	0.55
4	0.76	0.24	0.28	0.57
5	0.23	-0.23	0.18	0.48
6-8	0.31	0.33	0.31	0.66
Other	-0.38	-0.07	0.02	0.11
3	-0.36	-0.11	-0.02	0.11
4	-0.35	-0.13	-0.02	0.11
5	-0.37	-0.07	-0.07	0.11
6-8	-0.39	-0.05	0.06	0.11
Total	-0.38	-0.07	0.02	0.11

SY2019

Treatment	0 (not FAY)	1	2	3 or more
Montessori	-0.01	0.24	0.24	0.57
3	0.15	0.07	0.13	0.68
4	-0.26	0.28	0.38	0.47
5	-0.12	0.26	0.37	0.54
6-8	0.08	0.32	0.23	0.58
Other	-0.37	-0.07	0.01	0.12
3	-0.35	-0.11	-0.03	0.11
4	-0.35	-0.12	-0.04	0.11
5	-0.37	-0.10	-0.07	0.12
6-8	-0.39	-0.05	0.04	0.13
Total	-0.37	-0.07	0.01	0.12

Standardized residuals for student ELA scale scores statewide in Arizona were aggregated by school year, student grade group, Montessori school status, and Arizona's full academic year (FAY) indicator. FAY indicator scores of 1, 2 and 3 indicate the number of continuous years a student has been enrolled in the school. A FAY score of "0" was assigned to students that entered the school sometime after October and before spring testing. Again, the statewide grade level mean was 0.0 with a standard deviation of 1.0. The difference between statewide and treatment group scores represent effect size of the treatment.

SY2017

Treatment	0 (not FAY)	1	2	3 or more
Montessori	84	357	248	1740
3	22	84	89	392
4	22	75	38	402
5	16	70	32	330
6-8	24	128	89	616
Other	44882	132436	104005	223985
3	8039	17782	13197	46823
4	7809	18168	13878	46159
5	7573	17399	14287	45620
6-8	21461	79087	62643	85383
Total	45609	133982	105062	226761

SY2018

Treatment	0 (not FAY)	1	2	3 or more
Montessori	102	322	348	1745
3	19	72	104	393
4	21	76	64	369
5	21	55	63	374
6-8	41	119	117	609
Other	44606	132988	97510	235778
3	7643	17066	11059	47598
4	7842	17973	12337	48427
5	7486	17792	12804	49191
6-8	21635	80157	61310	90562
Total	45124	133930	98196	238303

SY2019

Treatment	0 (not FAY)	1	2	3 or more
Montessori	115	342	295	1891
3	30	80	99	396
4	24	68	48	394
5	22	65	54	378
6-8	39	129	94	723
Other	44037	133904	97913	236762
3	7290	16729	10587	46056
4	7405	17174	12127	47823
5	7385	17937	12842	49836
6-8	21957	82064	62357	93047
Total	44152	134246	98208	238653

From the comparison of treatment and non-treatment group standardized ELA scores by FAY and grade level, students achieve at higher levels the longer they remain in the treatment setting. All grade groupings (3, 4, 5, and 6-8) achieved higher standardized scores in the FAY 3+ group compared to all other levels of FAY in all years presented. FAY 3+ students in the non-treatment group also had higher scores compared to lower levels of FAY, though still well below the levels of the Montessori treatment group.

Not surprising, but quite telling, is the result below. Compared to the statewide sample of students, which has a mean score of 0.0 and standard deviation (sd) of 1.0, the 2019 Montessori scores show significant differences for all levels of FAY, except FAY=0. Since FAY 0 students are new to Montessori schools from the larger Arizona context, the -0.01 effect size shows us that students moving into a Montessori model in 2019 were similar to the larger Arizona student population from which they came.

FAY Level and Aggregate Performance of Montessori Students

FAY Level	Treatment (Montessori)			Significance Testing			
	N	score	sd	t	lower	upper	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	1891	0.57	0.92	26.94	0.53	0.61	<0.0001
TOTAL	2643	0.46	0.96	24.63	0.42	0.50	<0.0001

Also apparent from the scores is that though one or two full-academic years in the Montessori setting are significantly impactful on student performance, with good effect sizes of 0.24, students that remain in a Montessori setting for 3 or more years benefit the most (0.57) and in a big way.

The gap between the treatment group and others is sizeable and consistent. Though the metric of standard deviation units may not naturally conjure the magnitude of the difference Montessori schools make, the results of other groups (such as English learners detailed below) help provide some additional context and interpretation to these analyses.

English Language Learner Performance in Montessori Schools

	EL	English Proficient	Difference
Montessori	-0.76	0.49	1.25
ARIZONA	-1.06	0.08	1.14

English learners represent 1.64% of the Montessori treatment group in 2019 (compared to a statewide rate of roughly 6%). The small numbers do not allow for a disaggregation by the FAY indicator. The absolute difference for both Montessori schools (1.25) and the state non-treatment group (1.14) was more than a standard deviation between EL students and English proficient students. Ostensibly, EL student scores are based on performance on a test in a language in which the students are not proficient. The gap between EL and language proficient students nicely contextualizes the gap in effect size in other standardized scores in this report.

Special Education

Special education (SPED) students are a diverse group, and student level disability category details were not available in the restricted-use data sets. But from the SY2019 data, the Montessori group had a proportionate and sizeable special education count—369 students, or 14% of tested students, compared to 12% in the statewide test data. The similarities end there, though. The Montessori treatment 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). Considering the FAY information, the gap between SPED and others in the Montessori sample seem to attenuate when students in that setting for "1 or fewer" years (a gap of 0.87) is compared to the "3 or more" years group (0.78). But the control group saw the gap grow from 1.01 in the "1 or fewer" group to 1.09 standardized score units in the "3 or more" grouping.

**Standardized Performance of Treatment/Control Groups for Special Education and Non-Special Education Students by FAY**

Treatment	Other	SPED	Total
⊟ **Montessori**	0.58	-0.23	**0.47**
1 or less	0.29	-0.58	**0.18**
2	0.38	-0.62	**0.24**
3 or more	0.68	-0.10	**0.57**
⊟ **Other**	0.14	-0.91	**0.01**
1 or less	-0.02	-0.99	**-0.13**
2	0.14	-0.95	**0.01**
3 or more	0.25	-0.84	**0.12**
Total	0.14	-0.91	**0.01**

Treatment	Other	SPED	Total
⊟ **Montessori**	2260	369	**2629**
1 or less	388	55	**443**
2	254	41	**295**
3 or more	1618	273	**1891**
⊟ **Other**	444776	59625	**504401**
1 or less	149834	19938	**169772**
2	85910	11973	**97883**
3 or more	209032	27714	**236746**
Total	447311	60523	**507834**

SY2019 Standardized Test Results for Special Education Students by Years FAY, Comparing the Montessori Treatment Group to the Statewide Control Group

From the chart to the right, stability in setting seems to serve special education students well, however the impact is more dramatic in the Montessori treatment group.

Since the FAY indicator truncates student history in the educational setting to just 3 years, it would be worth investigating if the impact the Montessori treatment setting has measurable increases in years, 4, 5, 6 and beyond, particularly when you consider the non-SPED data below with a similar dramatic increase in the FAY "3 or more" category. With no apparent drop-off in special education enrollment in the middle grades (the numbers are actually


a little higher in terms of student enrollees) the impact on performance at the "FAY 3 or more" level is not likely due to students leaving Montessori schools. It is noteworthy there is really no statistical difference between special education students with three or more years exposure to Montessori methods and curriculum when compared to the general Arizona population with all levels of FAY (-0.10 compared to 0.00). These findings are consistent with the child-centered approach of Montessori schools.
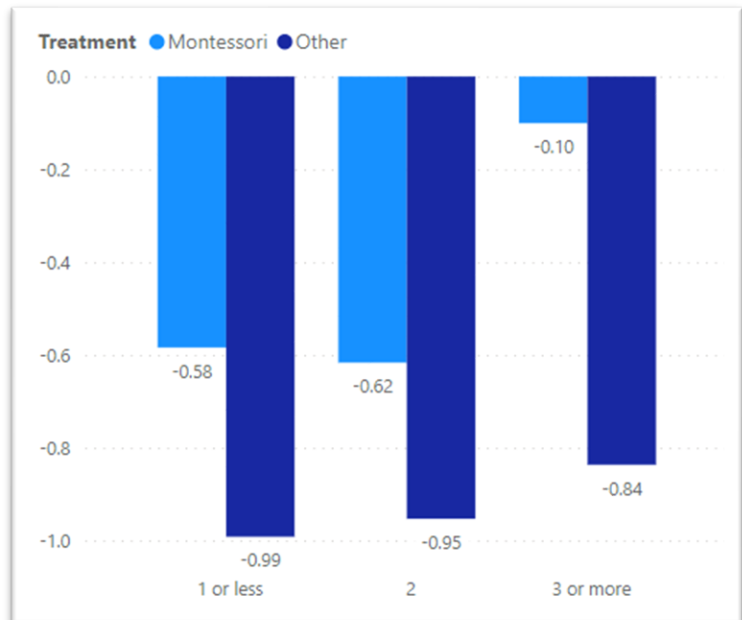
Special Education Student Performance in Arizona Montessori Schools on 2019 Statewide ELA Test, Grades 3-8

FAY Category	Treatment (Montessori)			Significance Testing	
	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

SY2019 Standardized Test Results for ALL STUDENTS by Years FAY, Comparing the Montessori Treatment Group to the Statewide Control Group
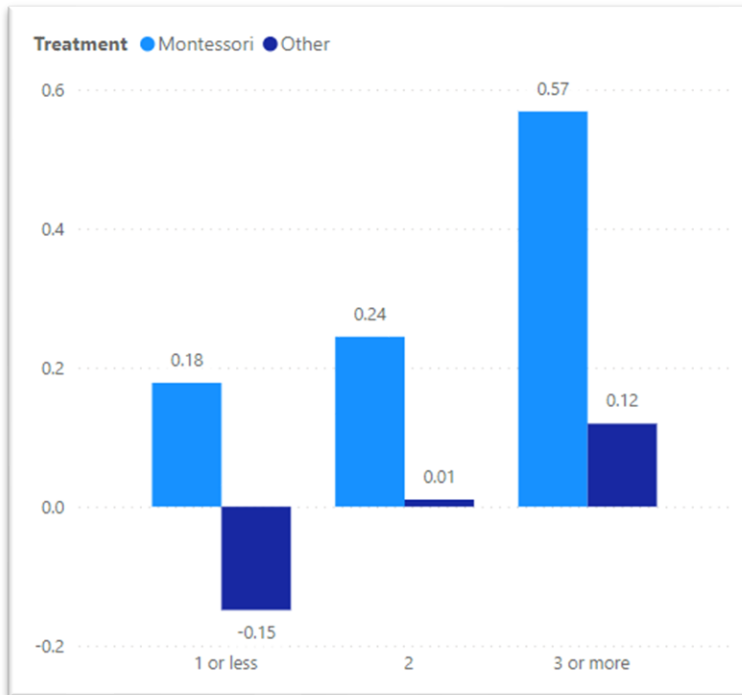
Similar to the benefit special education students appear to receive by remaining in the Montessori setting, all students (the majority of which are not students with disabilities) have their most dramatic results in the "3 or more" category of FAY. This group was 71 percent of the treatment sample in SY 2019 (compared to 46% in the larger Arizona comparison group). Montessori programming retained students at a higher rate as well as proved to be academically effective.

Regression Analysis

An ordinary least squares regression was run 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, and race indicator (dichotomously coded as white/non-white) and Hispanic group indicator (Hispanic/not Hispanic). The model was run for all 2019 test and student data (n = 516,152). Though the amount of variance explained was quite modest (about 27 percent), all variables in the model proved to be significant, and overall the model was significant ($p < 0.001$).

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.517[a]	.268	.268	.85506376

a. Predictors: (Constant), hispanic, SPED, schoolfaystability, ell, lunch, white

b. Dependent Variable: Zscore(scalescoreresult)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	137970.677	6	22995.113	31451.296	<.001[b]
	Residual	377371.904	516146	.731		
	Total	515342.581	516152			

a. Dependent Variable: Zscore(scalescoreresult)

b. Predictors: (Constant), hispanic, SPED, schoolfaystability, ell, lunch, white

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.014	.004		-3.600	<.001
	SPED	-.998	.004	-.321	-269.339	<.001
	ell	-.836	.005	-.198	-162.353	<.001
	lunch	-.320	.003	-.159	-125.637	<.001
	schoolfaystability	.127	.001	.131	109.966	<.001
	white	.302	.004	.145	85.430	<.001
	hispanic	-.085	.003	-.042	-24.852	<.001

a. Dependent Variable: Zscore(scalescoreresult)

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-2.2515099	.6700771	.0059071	.51701672	516153
Residual	-4.22847843	4.41214180	.00000000	.85505879	516153
Std. Predicted Value	-4.366	1.285	.000	1.000	516153
Std. Residual	-4.945	5.160	.000	1.000	516153

a. Dependent Variable: Zscore(scalescoreresult)

From the model, predicted scores that take into account demographic and student program differences data were used to create a database of student-level predicted scores. These predicted scores control for any test score advantages groups may have in the next set of analyses. For instance, the impact of FAY on scores on both the Montessori treatment group as well as the Arizona-wide control group was apparent. Predicted scores would control 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 above. The resulting measure estimates the difference between "predicted" scores and the "actual" scores achieved by tested students in the 2019

school year. The table below shows that the Montessori treatment resulted in 0.227 standard deviation bonus in actual scores not accounted for by FAY, school lunch data, EL, SPED and race/ethnicity of the student body. This is a significant effect size and indicates that Montessori methods and instruction has a significantly positive effect on student reading and language arts test scores independent of student background and experience.

Group Statistics

	Montessori	N	Mean	Std. Deviation	Std. Error Mean
ObsvPred	0	512634	-.0001	.85442	.00119
	1	2643	.2267	.88560	.01723

Independent Samples Effect Sizes

		Point Estimate	95% Confidence Interval	
			Lower	Upper
ObsvPred	Cohen's d	-.265	-.304	-.227
	Hedges' correction	-.265	-.304	-.227
	Glass's delta	-.256	-.295	-.217

a. The denominator used in estimating the effect sizes.

Cohen's d uses the pooled standard deviation.

Discussion & Conclusion

From the data, Montessori programs have prepared students quite well to face the rigors of the Arizona's state ELA tests. From the full-academic year (FAY) data detailed throughout the results, families that 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. Spanning all years and grade levels examined, and across all groups explored in this paper, Montessori schools and the curriculum and methods they employ with students outperform their statewide counterparts. Students that had not completed a full year of the Montessori curriculum in 2019 were statistically (and practically) no different than the general population in Arizona on the state tests. Thus, the data show that application of the Montessori method accounted for the improvement in performance.

Indeed, even for the most academically challenged students—those with learning disabilities and English learners—Montessori methods and curriculum showed great promise. Students in both groups scored significantly higher than their group peers across Arizona. What's more, special education students that received three or more years of continual Montessori instruction were statistically indistinguishable from the general Arizona student population on state standardized test scores. These results are not surprising in hindsight, given the student focus of a Montessori setting, though the magnitude of growth in special education students from successive years FAY was unexpectedly impressive (nearly an entire standard deviation greater than their statewide peers).

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

From the regression analysis we learned that the effect of the Montessori methods and curriculum had a significant positive effect on student outcomes, independent of student demographics and poverty, program differences, and years in a school (FAY) by comparing predicted student scores to the actual observed scores from the 2019 school year.

Virtually all of the evidence from the descriptive statistics, t-tests, and the regression modeling points to the conclusion that Montessori reading and English language arts instruction is better than being merely an acceptable option for schools to teach students to read—it is an exceptional option.

Montessori Literacy Committee

Sources Cited

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