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TRANSITIONING FROM MONTESSORI TO TRADITIONAL MATHEMATICS: A THIRD AND FOURTH GRADE CASE STUDY IN CENTRAL AMERICA

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Abstract. This study investigates three particular aspects hypothesized to affect the transition between a third grade Montessori mathematics class and a fourth grade non-Montessori mathematics class. These aspects are (a) the change in pacing and structure of the classroom, (b) the removal of manipulatives in favor of handwriting methods, and (c) the reversal of roles that teachers and students occupy. The effect of this transition on problem-solving skills is analyzed through mathematical metacognitive tools. Overall results show that students identify alternative strategies when uncertain how to proceed in a problem, particularly reverting to previous object-centered methods when having difficulty. The use of manipulatives is one of the most influential aspects of the transition, followed by the shift in student and teacher roles. The pacing and structure of the classroom has minimal effect.

1. Introduction

This study analyzed three aspects that affected the transition from the Montessori method (MM) into a direct style of learning, within the scope of third- and fourth-grade mathematics curricula. Often, MM focuses on “students [who] can be described as self-regulated to the degree that they are metacognitively, motivationally, and behaviorally active participants in their own learning process” ([63], p.329). MM was founded and developed in Europe by Maria Montessori in the late 19th century to serve slower developing children, before eventually expanding to an alternative learning style for all students across the world ([18], [56]). A push for schools to use MM in the United States began in the 1960s, with the allure of a child-centered curriculum ([18], [39]). The modern structure of MM includes a classroom filled with tangible subject-related objects for students to manipulate, play with, use, understand, and share, with a teacher present to foster a curiosity-based environment that keeps students engaged in discovery ([3], [35], [39]). The three stages of using mathematics manipulatives should be the concrete stage (materials), the representational stage (drawing), and the abstract stage (algebraic symbols). Further, research comparing and contrasting MM and more “traditional” methods has shown some disparity in student success and experiences ([13], [57]). Research on the shift in learning style throughout such a transition is limited ([13]). Previous research on transitions has not provided adequate evidence pertaining to the shift from MM to traditional methods ([13], [43]). Further, “both the [Montessori] method and the movement remain largely unstudied by mainstream educational researchers” ([14], p.212). The intention of this study was to fill a gap in knowledge utilizing the opportunity to observe fourth graders newly introduced to a different learning style after concluding their third-grade year under the host school’s perceived MM.

1.1 Problem Statement and Application

This study sought to explore three hypothesized aspects related to difficulty in student transitions. A problem had been identified from the previous school year, concerning students exiting a program using MM after third grade and entering a more direct-instruction environment in fourth grade and beyond, indicative of potential global issues. The results can be broadly applied to many mathematics students experiencing the same shift in educational environments. This study followed students in primary grades at a single campus serving PreK-12 grades, eliminating consideration for changing settings or middle school environments, variables commonly referenced in studies post-MM ([1]). Similarly, research acknowledged elementary education as vital in students’ processes to becoming higher order thinkers ([11], [58]).

1.2 Evaluation Questions

It is of critical importance to explore MM in order to understand successful students transitions. The transition can be addressed as a set of observed factors to evaluate the pedagogical shift between grades. The following questions help evaluate this transition in detail, then elaborated upon to highlight their importance to the conclusions in the study:

1. To what teaching practices and learning opportunities are third- and fourth-grade students exposed? To what extent are these practices and learning opportunities related to the MM approach?
2. How are three particular aspects of current teaching practices and learning opportunities in fourth-grade mathematics perceived by students and teachers compared to their previous exposure in a classroom implementing MM?
3. How, and to what extent, does changing the teaching practices and learning opportunities affect the problem-solving strategies of students?

Based on the related research, three aspects (referred to in the second question) were hypothesized to have the most influence on the transition: 1) the implemented learning pace and discovery style of the class, 2) the shifting focus away from materials toward handwriting methods, and 3) the difference in the roles students and teachers occupy during the transition.

1.3 Three Possible Influencing Aspects

For the first aspect, change in learning pace was expected to influence the transition based on the differences in MM and non-MM. In a program using MM, students are tasked with responsibility for their own learning, and discoveries are meant to come naturally when students realize mathematical connections for themselves. In traditional programs, students instead experience a passive environment in which the teacher provides knowledge directly, without regard to pacing or timely understanding ([13]). The second aspect was evaluating the different methods based on the contrasting ways students express and defend their answers. [32] states that teachers using MM support two differing perspectives: the system is based on dialogue alone, or that manipulatives are essential — neither focuses on written justification. Further, MM experts were universal in denouncing mathematics workbooks and worksheets ([32]). However, many students who move away from MM and into a program with non-MM are requested to use pencil and paper to physically construct and write down their thoughts and solutions. This approach, new to the student, represents a shift in methodology for each learner, whose adjustment time could be substantial. The third aspect analyzes the changing roles of students and teachers across transitions from teaching using MM to more traditional teaching methods. In MM, students are considered self-regulated and responsible for their learning, with the teacher as a guide in the classroom. Once students move out of MM, a dramatic shift in roles can create turmoil. Such changing classroom relationships may cause chaos in the learning experience ([17]), and both parties may have trouble adjusting and understanding their new classroom roles.

2. Literature Review

2.1 Metacognition as an Appropriate Framework

Using metacognition as a theoretical framework for this pedagogical exploration is appropriate with respect to the self-motivated thinkers encouraged by MM. We aim to explore student processes and experiences during this difficult transition stage over the course of an academic year. In "Dr. Maria Montessori's work [she] repeatedly and emphatically referenced metacognition, emotional intelligence, preparation for life, and the impact of these skills on student success" ([24], p.3). [34] defines metacognition as active control over the cognitive process, allowing successful learners to engage and display their higher order thinking skills. The benefits of metacognition include self-motivation and behavioral awareness ([61]), and even simpler, "the ability to know what we know and what we don't know" ([15], p.5). For mathematics, [47] describes metacognition as providing focus for solving problems and reflecting on successful and unsuccessful strategies, while teachers using MM are encouraged to implement metacognitive teaching strategies in general ([3], [33]). "[M]etacognition has a dual role: (a) It forms a representation of cognition based on monitoring processes; and (b) exerts control on cognition based on the representation of cognition." ([19], p.4). Motivation and belief impacts performance, persistence, and creativity ([53], 2000). MM utilizes a curriculum that focuses on metacognitive skills such as reflecting, organizing, and planning ([3], [38]). Research suggests that more self-aware, self-driven students, also referred to as autonomous students, who took the time to discover results for themselves were more likely to retain the information in the future than a student who was given knowledge directly ([22]). Students using MM have opportunities to exercise control over many aspects of their daily lives and learn to attribute success and failure to their own actions based on direct experience with the consequences of their decisions ([41]).

Research has shown quality mathematical class discussions can create positive effects on all cognitive levels in the classroom, which allows advanced students and beginning students to excel together, rather than becoming passive or being left behind ([26]). Cooperative methods beyond the individual are considered the most relevant teaching strategies for mathematics ([21]). This approach requires students feel comfortable sharing their findings and supporting their own ideas, and students with metacognitive conditions can reach higher overall achievements than those without ([28]). MM "is supportive for exploration and early discovery of mathematical ideas and relations as well as for development of mathematics reasoning" ([37], p.138). As with many mathematics classrooms, "teachers need to know how to draw students' identities into the mathematical work, support them to evolve in how they participate, honor different forms of participation, and structure opportunities that allow for different participation forms" ([21]). Often, teaching strategies require time to eventually change the behavior of the students ([45]). A constructivist may consider requiring students to defend and discuss their ideas the pinnacle of successful mathematics classrooms ([54]). Cognitive theory suggests that children should be encouraged, not directed, to explore and discover ([5]).

2.2 Filling a Gap in the Literature

Although research shows issues in K-12 transitions such as changes in campus location or grade level, "aspects of transition such as changes in student academic performance, student social and emotional functioning, family dynamics, and effects on teaching have rarely been the focus of research attention and empirical work" ([57]). Similarly, much research has focused on the traditional school systems, there has been a lack of research on MM ([36]), perhaps in part to a lack of "standard guideline[s] describing 'best practice' of implementing MM ([59]). Absent traditional forms of assessment, it is challenging to draw comparisons between different programs using MM, or between programs using MM and other programs ([33]). The literature that exists regarding the success of teaching with manipulatives, for example, is inconsistent at best ([29]), but other research reveals MM is the only form of curriculum to truly integrate topics such as mathematics ([37]).

2.3 Further Defining the Montessori Method

MM "aims at developing children's senses, academic skills, practical life skills, and character" ([35], p.3). Students utilize objects, termed "manipulatives", to envision abstract ideas and to interpret those ideas in multiple ways; to create appropriate understanding by eventually using their words and descriptions as the solution itself, particularly to transition thought processes from the concrete to the abstract ([7], [28]). Teachers collaborate outside of the class environment to adjust their teaching style to help individual students benefit most from exploration ([18]). This student-centered experience reflects how "Montessori defined education as a dynamic process in which children develop according to the 'inner dictates' of their life, by their 'voluntary work' when placed in an environment prepared to give them freedom of expression" ([23], p.47). This self-determination theory assumes, rather than forces, the concept that every student has particular psychological and growth tendencies that require a motivational environment to maximize ([53]). "The theory further assumes that students are always in active exchange with their classroom environment and therefore need supportive resources from their environment to nurture and involve these inner motivation resources" ([51], p.226).

2.4 Defining a Traditional Method

Compared to MM, more traditional approaches to a classroom focus on procedural development rather than inquiry-based skills ([9]). "Remarkably, in traditional classrooms there is not much room for self-regulated learning. Students are cognitively, emotionally, and socially dependent on their teachers who formulate the learning goals, determine which type of interaction is allowed, and generally coerce them to adjust to the learning environment they have created" ([6], p.594). An emphasis is placed on pacing students together to view the teacher as the authoritarian source of information on a subject matter, collecting handwritten assignments. Traditional methods are further defined as when "the teacher delivered direct instruction and controlled behavior; students followed directions, recalled knowledge, and worked individually" ([60], p.251). Traditional mathematics education focuses on procedural development rather than inquiry-based development, leading to claims that traditional forms of teaching are obsolete ([9]), although several studies have found direct instruction is the quickest way to improve test scores for students who struggle or have learning difficulties ([40]). Similarly, research has shown that conceptual knowledge improves if direct teaching is not the only method in the classroom ([48]).

2.5 Evaluating the Transition

Research that directly evaluates transitions away from MM in mathematics classrooms is rare, but relevant established research on the topic exists. For example, some early childhood teachers found the lack of direct instruction in MM schools unnerving, claiming that "the environment may provide 'the food for mathematical thought', but the existence of mathematical food for thought in a classroom does not guarantee that children will ingest it, let alone digest it" ([30], p.42). [43] found that students cite a noticeable reduction of personalized relationships when moving from a non-traditional style to a traditional classroom style, and students reported this problem more frequently as class size increased — their "educational setting…can make or break [students]" (p.176). The limited research does suggest that students from task-focused elementary instruction experience fewer negative transitions to standard methods in middle school ([1]). Whereas MM allows students to be responsible for their own knowledge and growth, the traditional style dictates teachers as absolute sources of knowledge and classroom managers ([13]). Further studies suggest that students raised using MM have "higher intrinsic motivation, interest, and flow experience in academic work" when compared to students in a traditional middle school setting ([50]). "Unlike their passive classmates, self-regulated students proactively seek out information when needed and take the necessary steps to master it" ([62], p.4), although this is not unique to MM. Students who leave a program using MM usually do so when changing schools and entering middle school. While some may attribute this decreased performance due to puberty and pre-teen attitudes, many researchers claim it is instead a disparity between the development of the child and their learning environment ([49]).

2.6 Relevance and Importance to Elementary Mathematics

Elementary students possess the ability and interest level to be full participants in mathematics, and such foundational development naturally begins at a young age ([11], 2007), which lends significant importance to the age range of students in this study. "We have neglected far too long the teaching of mathematics in elementary school. The notion that 'all you have to do is add, subtract, multiply, and divide' is hopelessly outdated. We owe it to our children to adequately prepare them for the technological society they live in, and we have to start doing that in elementary school" ([58], p.14). Students' basic views and thoughts about mathematics are shaped in the elementary years, and these views can be difficult to change later in school ([52], [58]). This philosophy of thinking has been supported for years, for example by [2] back in 1967, as "it is no longer possible to believe that the learning of mathematics properly begins in the secondary school, and that the only essential preparation for this stage is a certain minimum of computational skills in arithmetic" (1967, p.3). Third grade focuses on developing independent thinking and confidence through problem solving ([26]), important in mathematics education because students who simply memorize steps are thought to be setting themselves up for failure in higher levels of mathematics ([27]). [42] emphasized this claim by announcing that "tasks that encourage students to use procedures, formulas, or algorithms in ways that are not actively linked to meaning, or that consist primarily of memorization or the reproduction of previously memorized facts, are viewed as placing lower-level cognitive demands on students." Although students are more successful when a problem's context makes sense and feels personal, not enough students are able to make these connections ([44]). "Important learning can occur after a correct answer is given when a child is asked to articulate, reflect on, and build on initial strategies" ([25], p.272). Students who struggle to get started on word problems learn to identify the mathematical relationships within the problems and use them to their advantage ([8], 2015).

3. Methodology

3.1 Sample Selection and Population Description

Focusing on three identified potential factors contributes to establishing the scope of this study. These three factors are highlighted in Table 1.

Table 1
Differences Between Montessori and Traditional

Montessori Method	Traditional Method
Hands-off teacher guide	**Teacher as direct source of knowledge**
Self-paced, eventual learning	**Scheduled, structured lessons**
Lack of focus on grades	Grade and rank intensive
Manipulatives and objects used more	**Pencil-and-paper work stressed**
Focus on relationships	Less personalized relationships
Typically elementary ages	Audience of all ages
Discussion and group based approaches	Rigorous exercises and many assessments

This study took place in a coastal town on the west side of Central America. The school is International Baccalaureate-certified (IB), with a high school curriculum not implemented in the standard Central American public school system. The lower grades are taught in preparation for this upper level IB curriculum. The school is private, and served approximately 135 students during the course of this study, ranging from pre-kindergarten to 12th grade. Total attendance numbers were approximate due to international students' tendency to relocate. The school's predominant language of instruction is English, though some students at the time of study spoke it as a second language. Each student is enrolled in English as well as Spanish classes from an early age, and is expected to be fully bilingual by the time of graduation. During this study, more than twenty countries represented the diverse population of the school across the grades, and there were no comparable schools in the surrounding area. This school uses a trimester system; the first trimester ran from September 1 to December 14, the second trimester from January 3 to March 31, and the third trimester from April 24 to June 29. This study took place during the first and second trimesters to maximize the opportunity to collect data at the peak of student transition.

During the academic year of this study, there were 12 third-grade students enrolled and 16 fourth-grade students. Among third-grade (MM) students, one student was new to the program, two students in their second year, five students in their third year, and the rest of the students had begun at the school during pre-K. Among fourth-grade (non-MM) students, two were in their first year at the school (little to no experience with MM), two students were in their second year (third-grade MM experience only), two students were in their third year (second- and third-grade MM experience), four students were in their fourth year (first-, second-, and third-grade MM experience), two students took a single year break having left the country before returning, and the rest of the students had started at the school in pre-K programs. Five fourth-grade students were identified from the group of sixteen for further analysis. This analysis was conducted using metacognitive mathematics tools, to specifically target the third evaluation question regarding effects on problem solving skills. Participant selection was based on average academic performance, cross-referenced with three to four years of experience in the program using MM, and teacher recommendations, leading to a qualitative sample of five students from the population of 16 fourth-grade students.

3.2 Beginning Observations and Interviews

To address the first evaluation question (To what teaching practices and learning opportunities are third- and fourth-grade students exposed? To what extent are these practices and learning opportunites related to the MM approach?), ten interviews and observations were conducted in each grade to assess the extent to which the systems using MM and non-MM had been implemented for students transitioning at the school. Comparisons and correlations were made between those observations using field notes. Two observation tools adapted from the RTOP (Reformed Teaching Observation Protocol) ([46]), were created specifically for this study to pinpoint exact relevant characteristics for both forms of education. The edited tools were named the MTOP (Montessori Teaching Observation Protocol) and the TTOP (Traditional Teaching Observation Protocol). The MTOP and TTOP each contain a rating scale generated from similar statements in the RTOP, combined with unique statements derived from literature about MM and traditional styles of classrooms; these twelve statements represent the respective classroom structures. During observation, these statements were ranked from "never occurred" (0), to "very common" (4), in order to evaluate the alignment of the classrooms to their theoretical formats. A (3) or (4) score on this ranking meant the statement accurately reflected the classroom, while anything lower suggested a lack of appearance. This tool was not intended to quantify the observations statistically, but instead to qualify the degree of alignment of instruction with the respective educational theories. Pictures and videos were taken to revisit particularly insightful moments in the class, and to provide extra detail with potential quotes beyond the one-on-one interviews. The MTOP and TTOP are included in Appendices A and B, respectively.

Teacher and student interviews were important for understanding some thought processes experienced while progressing through the school year, including predisposed thought, qualities noticed, changing ideas, struggles or strengths, and growth of the program. Teacher interviews supported classroom observations in determining the extent to which third- and fourth-grade classrooms aligned with MM and non-MM. Interviews with teachers also provided pertinent information such as role identification, opinions on the curriculum and pacing of the students, strengths and weaknesses of the classroom, and details on instruction and scheduling. Student interviews revealed more experiences, metacognitive comparisons of the learning opportunities, thoughts and opinions on the current experienced style, and classroom qualities students found successful. The interview templates (Appendix D) included metacognitive questions covering the way mathematics was taught, and student and teacher opinions about the perceived value added by learning mathematics. Fourth-grade Student and teacher interviews also provided perspectives and comparisons of how their roles changed from the previous school year. Data for the first and second evaluation questions was then coded and analyzed; many of the words, thoughts, phrases, and expressions that students expressed in these interviews presented patterns and trends.

Two third-grade teachers and two fourth-grade teachers were interviewed three times each throughout the year. These teachers shared the responsibility of classroom management and curriculum development. Their education experience varied; one third-grade teacher had no experience with MM, the other had three years of experience with MM. The fourth-grade teachers had over 20 years of education experience each, between curriculum building and classroom teaching. Each student was interviewed once strictly about the classroom environment, and the extra five selected students were interviewed one additional time, both interviews using what we will call metacognitive mathematics tools for problem solving. These five students were given twelve problems to solve, one set of six problems in October and one set in March; each set aligned with appropriate curriculum expectations. A selection of open-ended problems taken from “Formative Mathematics Assessments for Use in Grades K-3” ([20]) was used to generate the metacognitive mathematics tools for this study. One strength of this tool was the assessment of problem solving skills provided by the existence of multiple viable strategies for these problems. The tool is included in Appendix C. Notice the blanks provided in these problems (provided by [20]) were to be used by the task administrator to individualize the assessment in order to allow students to struggle, but still make progress, through enough of eacjh problem for successful observations of their processes.

4. Results

4.1 The First Aspect: The Changing Pace and Structure

Students entering fourth grade experienced a substantial change in classroom structure and pacing. Though the third-grade classroom closely represented many characteristics of the MM philosophy, the fourth-grade classroom was structured quite different. Third-grade students experienced an exploratory style of education, which requires a certain amount of work to keep themselves on a general path forward, but their academic progress was neither accelerated nor hindered by ability. As first-, second-, and third-grade students were taught in the same classroom, third graders could take on roles with greater leadership. Students enjoyed instructional freedom to continually revisit difficult types of problems individually, while classmates could potentially advance deeper within the topic. Teachers explained that students were placed at different content levels based solely on ability, rather than age or grade level. One major divergence away from typical systems using MM was the inclusion of a weekly mini-lesson for each subject. Though the lesson groups were small, this idea is extremely uncommon in the typical classroom with MM, which places great value in students leading themselves through lessons. Further, teachers instituted a “follow-up” strategy to require more short-term accountability from students throughout the week. This strategy, combined with weekly homework benchmarks, kept students moving forward at a pace not entirely set by intrinsic motivation. However, students were also encouraged to work in groups and assist others, occasionally tutoring their classmates on confident topics. In fact, this third-grade mentality, a direct result of MM, was fully encouraged all day—this was one of the most consistent aspects observed in the classroom.

In comparison, the teachers utilized whole group instruction with the fourth-grade students. Teachers implemented consecutive lessons from a book in a repetitive nature to establish a routine for student practice and exposure. Lessons were delivered to the entire class at the beginning of the mathematics period. Afterward, students were expected to drill and repeat the strategies they observed during the lesson, in an individualized structure rather than with a group. Students were not actively encouraged to help others. Instead, teachers emphasized individual advancement. Observations also showed that students were called on individually to share their solutions or strategies, rather than communicating in pairs or groups.

The pace and overall style of learning clearly changed from third- to fourth-grade. Many times, the third-grade teachers encouraged natural occurrences of students helping others to learn a new topic. Fourth-grade teachers, however, often separated students in order to prevent any collaboration. The third-grade classroom environment provided students a way to explore topics one at a time, with a chance to build a contextual foundation. While typical MM provide minimal structure on what needs to be achieved, this third-grade classroom required a minimum workload of three activities per day. Fourth-grade students expressed that this former workload with MM was not heavier than they had experienced prior. Similarly, even though there was more to accomplish in the current year, fourth-grade students did not negatively respond to the new amount of work. Many students appreciated the direct instruction because they perceived that they were learning more and progressing at a faster rate than they had with MM. The limited inclusion of lessons, assessments, due dates, and written assignments in a classroom using MM appeared to prepare fourth graders for the new style. Many fourth graders felt the workload may have changed, but not significantly enough to induce stress.

Fourth-grade teachers did not emphasize differentiation, but student responses suggested that they did not feel intimidated asking others for help during the instruction period. MM was clearly effective at instilling in students a sense of individual pride in their work, evident from students' repeated comments on independent work and from their willingness to persevere through challenging problems. Students were able to express their strengths and weaknesses in attempts to better themselves as learners, which confirmed their status as self-motivated learners. Students displayed awareness of both their pace and how successfully they moved through the curriculum. This focus on individualism in fourth grade was a major difference for students transitioning from MM. Facilitated conversation and cooperation were consistently present in the third-grade classrooms. Neither third- nor fourth-grade students expressed intimidation when comparing themselves to others, suggesting that pace did not bother students—they did not try to compete with classmates. Fourth-grade students seemed to enjoy the new direct scheduling of assignment completion, and most of them responded positively about this type of structured schedule. The teachers often debated the level of direct instruction necessary for the class, but ultimately chose direct instruction over an exploratory environment. The two fourth-grade teachers each agreed that the lack of differentiation was a problem, but disagreed on which students were most detrimentally affected—students with low achievement performance or high achievement performance. However, the teachers agreed that a direct-instruction approach was the appropriate form for teaching mathematics. Many of the fourth-grade students spoke positively about the freedom to avoid group work if they chose, but others had a wide range opinions about their willingness to work alone before asking a friend or the teacher.

Each grade level aligned fairly well with its respective theoretical instructional modality: third-grade (MM) focused on group and eventual learning outcomes, and fourth-grade (direct-instruction) focused on promoting the individual with a more rigid schedule and heavier workload. Promoting individuality in the fourth-grade traditional classroom was observed less often than expected from the literature, but still was much more present than in third grade. The lecture-and-workbook style did not vary despite the diverse levels of abilities that students portrayed in the classroom, and students did not express a common sentiment toward this change. According to fourth-grade teachers, fourth grade had a more scheduled school day compared to third grade, particularly for mathematics, and one teacher further believed that mathematics students benefit most from a classroom using repetitive, traditional, non-MM instruction.

4.2 The Second Aspect: Removing Montessori Materials

Third-grade classroom observations revealed that manipulatives were an essential part of the experience using MM, but not the only learning method. First-, second-, and third-grade students all used manipulatives in the classroom as the original source of knowledge, but third-grade students were additionally tasked to transition their learning into handwriting. Students were asked to replicate material-based assignments in written format—eventually the primary method was expected to be handwriting. The ultimate goal of the handwriting stage was to use concrete symbols to represent abstract ideas. However, many third-grade students complained about working through material twice (once with manipulatives, once with handwriting), feeling the two methods were not connected. They acknowledged older students' use of handwriting in mathematics, and described manipulatives as slowing their own progress. To the students, manipulatives were not gradually phased out as concepts became more abstract, but were instead replaced with more efficient methods. Half of the third graders reported a slight preference for manipulatives, while fourth-grade students held more extreme opinions about the MM materials. Many fourth-grade comments were negative toward the manipulatives themselves, with few students appreciating their use. Further, the vast majority of fourth-grade students believed they achieved more in class without manipulatives. Thus, many fourth-grade students, believing materials inefficient, preferred their new class because they were no longer required to use them.

While student comments about manipulatives were mixed in the third-grade classroom, and fourth grade curriculum heavily favored the handwriting methods, all students who felt negatively toward mathematics and/or found the subject difficult favored materials over handwriting. Many other students admitted that manipulatives were helpful in the past, yet felt ready to move on without them. Students who had mastered their activities reported frustrations with being required to continue using manipulatives even when not cognitively necessary. For example, a student could look at ten blocks on the desk to visualize moving over to the tens place value. However, eventually the student no longer needs this visual aid, and some students reported feeling forced to continue using the materials regardless of cognitive necessity. At that point the manipulative use became somewhat of a hindrance to their advancement, and no longer made a positive impact on their learning. However, when facing new, less comfortable concepts, some of the students were more prone to draw pictures or simulate counting objects as a helpful strategy. Many students also perceived handwriting as more mature and helpful, while also less "boring" and "repetitive." Other comments indicated that handwriting made learning mathematics easier, describing a preference in working with an algorithm rather than taking the time to explore and discover the ideas for themselves—an unexpected lack of curiosity given the indicated environment with MM. Other students described the new topics and methods in fourth grade were challenging, and believed this was probably best for them as a learner. Some students insisted they needed to work through more difficult problems to be a balanced and improved learner, a process that also made mathematics more exciting.

The fourth-grade students were the focus for the transition stage in this study, and they often reflected on their experiences in the third-grade classrooms with MM. Manipulatives impacted students' perception of learning mathematics, but differently than predicted. Teachers believed students would struggle moving from concrete to abstract mathematics learning. Instead, students appreciated the decrease in material usage in the classroom, devaluing the original purpose of manipulatives. Like third-grade students, fourth-grade students often expressed displeasure in being required to connect the two different methods for the same task. They preferred handwriting, but did not enjoy the requirement of interpreting rules and instruction for manipulative-based activities to help them learn abstract concepts. These fourth-grade students perceived mathematics positively despite, or even in response to, the lack of manipulatives in the classroom. Only a few students missed the presence of manipulatives.

One of the third-grade teachers agreed with students that there was too much repetition in the curriculum using MM. This required students to remain on the same content rather than pushing forward, and also left less time for students to proceed further into more difficult topics. All teachers believed that manipulatives were effective in helping students master the abstract before moving on to handwriting methods, but the students found manipulatives less engaging long before reaching this stage. Further, the metacognitive mathematics tools provided evidence that over half of the assessed students worked algorithmically toward the solution, with little hesitation once they identified which operation should be used. This tendency highlighted their comfort level with many problem scenarios. Division brought out the largest variety of strategies from these students because of the unfamiliarity. Instead of working through a typical division problem algorithmically, students chose to use building addition, repeated subtraction, or multiplication strategies. Students either used familiar methods, or fell back on drawing pictures or counting fingers as a forced manipulatives strategy.

Observations revealed that third-grade students initially only used objects to work through their learning process, and classroom assessments were given strictly in this form before handwriting strategies were later learned. In the fourth-grade classroom, note taking and handwriting every problem became standard. The third graders for this study experienced much more handwriting than typical of MM. Student comments about manipulatives showed that students were educated in a system that gave them much of the power in the classroom, leading to greater drive and awareness of the learning experience—an important goal of MM. The words and phrases used by fourth-grade students did not suggest laziness or a low work ethic, but rather students' awareness of their own priorities and efficiencies. The students placed emphasis on the importance of mathematics as a subject, and did not want manipulatives to slow them down.

While manipulatives served their purpose initially, students were more ready to move forward without the materials than administration and teachers realized or planned. In the third-grade curriculum, students were usually expected to make the leap from the concrete stage to the abstract stage when handwriting problems. However, students naturally reverted back to individualized, familiar visualization strategies to process less familiar topics, showing students' natural inclination to use the representational stage not emphasized during the process of moving to handwriting skills. Fourth-grade student comments also reflected this fallback, as those who had more negative emotions toward mathematics exhibited a preference for continuing manipulatives. Students appeared to prefer algorithmic calculation in nearly all cases for addition, subtraction, and multiplication, because they were past the manipulatives stage. Through metacognitive mathematics tool analysis, two students who admitted struggles with the problems used these more creative visualization methods to approach the problems. They relied on pictures or counting imaginary objects, and were the only ones to maintain accuracy from the first problem set to the more difficult second set. In fact, these students faced fewer challenges in the second round than the students who preferred pattern recognition and algorithms. In summary, the MM materials' effect on transition had a large impact, but not how the staff expected.

4.3 The Third Aspect: Reversing the Teacher and Student Roles

The third aspect involved the reversal of student and teacher roles as the students moved away from MM and into a direct teaching style. In the third-grade classroom, evidence showed that the implemented program using MM provided students the opportunity to control the pace of their education and to approach the teacher for help as necessary. Meanwhile, teachers drifted around the room like guides and, outside of the brief lessons once per week, never lingered for an extended period of time with one particular student or group of students. Teachers deviated from this role when they took on the additional responsibility of providing brief lessons once per week. These lessons continued to have a place in the classroom, to both prepare students for fourth grade and to provide structure for young students. When students did not ask for assistance, they reached their own conclusions through discovery involving other students and repeated efforts to master a particular concept. Under MM, teachers consciously decided to draw back and not become too involved, because their natural tendency was to take an authoritative teaching role. By moving confidently forward in the guide role, the third-grade teachers maintained their capacities in fostering student-led learning well, and students actively gained the ability to be both self-motivated and aware of the importance of their education. Students also exhibited characteristics of an improving learner, by openly acknowledging their own strengths and weaknesses in both observations and interviews.

Once the students entered fourth grade, there was a complete reversal of roles and structure. Initially, one teacher used a direct form of instruction three days per week (and eventually five days per week), with a thirty to forty-five minute mathematics lesson to start the day. This schedule included warm-ups, homework review, new material, and group or individual practice. Alternatively, the other teacher sought to instill more values from MM into the fourth-grade classroom through the use of activities and games, but was unable to keep up with the lesson planning required, giving way to the other teacher's methods. While students appreciated both styles (experiencing them on alternate days), they reacted more positively to the traditional teaching style, because they felt it was more direct, efficient, and productive. Observations revealed that the teachers struggled to settle into their roles and define what they were looking for in the classroom. Students expressed willingness to adjust to these uncertain periods as teachers found their places in a system for students formerly using MM—they believed it was a learning experience for everyone involved. However, the students were also aware of the differences between the teachers, and felt comfortable expressing preferences. These acknowledgements showed that the ongoing shift in styles in the classroom indeed affected the adjustment period in transition.

With MM, students were taught to be active learners and to be in control of their own experiences in the classroom. Once they entered fourth grade, students were abruptly placed in a system where everyone was taught with the same concept expectations, and they received information from the same source: the teacher. For the majority of the time, students were in the role of passive learner to the teacher's authoritarian role, while teachers privately debated the effectiveness of this style. Third-grade observations revealed the implemented MM was aligned with theory and literature, but also had an additional emphasis on a structured schedule that is not typically emphasized. Fourth-grade observations indicated that the classroom was not only non-MM, but also a mostly pure direct-instruction style, especially for mathematics. Other content areas were given more of a free, exploratory structure, but the final mathematics schedule held strictly to a routine, lecture-based structure. Most students said they elected to focus on their mathematics class-work directly after the mathematics lesson, even though it was not technically required. This choice provided students a solid hour of direct instruction, drill and repeat, and practice with the teacher's methods. Students did not comment negatively toward this new direct-instruction style, but instead embraced the teacher as a source of knowledge for more efficient learning. Based on the analysis from interviews and observations, the teachers struggled more than students with identifying their own place in the classroom. While it is not uncommon for teachers to struggle with identifying their roles in the balance of discovery and direct learning in the classroom, consistency is essential for student success, particularly in this type of transition.

4.4 Conclusions and Tie-Ins

According to the literature, making the connection from the concrete manipulatives to the abstract symbols is a process that usually involves drawing visual aids as a transitional stage; the use of manipulatives themselves is more for mathematical understanding rather than algorithmic proficiency ([55]). For the students in this study, this was achieved only as long as meaning was still prevalent. Students only achieve mathematical understanding if they use the manipulatives as a tool rather than a requirement ([12]). Therefore, students need to build upon what they learn to grow mathematically ([16]), and the repetitive methods beyond mastery did not reflect this value. The school in this study provided a slightly different experience than typical programs using MM because of the classroom and curriculum formats. For example, when students leave programs with MM, they also usually switch institutions entirely. Because the transition at this school was contained within the elementary grades, this study benefited by viewing students that were consistently familiar with their classmates, faculty, and the environment. However, this is not the case for all schools, and the results of this study should be interpreted accordingly. This self-contained transition benefitted the reliability of the study, compared to other studies in which outside factors from changing institutions may influence the results.

A limitation to this study is that the studied group of fourth-grade students is not the same set of fourth-grade students from the previous year, when the problem was originally identified. The fourth-grade students from the previous year, in fifth grade during the study, were never observed. For a classroom using MM, the topics should be available to students based on readiness, not simply as part of a checklist ([31]), which is how third-grade teacher comments described the decision-making process. The classroom environment effectively facilitated conversation, and cooperation was consistently present, which is generally considered a characteristic of an effective learning environment ([10], [21]). With teachers as their guide ([39]), students place emphasis on the value of mathematics while challenging themselves with difficult problems, both key traits of a learner ([4]). The classroom not using MM proved to be traditional, following the model that traditional styles typically lead to a less personalized classroom, one that puts the teacher in absolute control ([17]). Both teachers assumed leadership roles in the classroom, in which they were sources of information for students, as direct-instruction styles dictate ([13]). Additionally, and perhaps clearly from the description of the setting, the data is certainly localized to this particular location, thus being designated as an explorative case study; it is accepted that conclusions can only be generalized so far as a result.

The results of the study contribute to the existing knowledge of teaching mathematics under MM, and also help fill the void in the literature regarding the transition stage away from MM and toward non-MM. Another important conclusion draws attention to the best implementation of the manipulatives stage of learning mathematics. Administration and teachers predicted that manipulatives could be the issue in the transition. However, only a few fourth-grade students reflected upon these materials positively, and many stated they preferred the new methods of pencil-and-paper, individual work, and direct teacher instruction. They also said they were happy to have the opportunity to approach the teacher in the fourth-grade classroom because teachers told them the fastest methods. In this study, the researcher had some issues translating what students conceptually understood compared to algorithmic handwritten procedures, which masked some of their problem solving abilities in the process. Programs using MM may provide students with solid mathematical understanding with physical objects and even direct modeling through drawing pictures. The issues arise when moving into the procedural stages, and future studies may explore this stage more fully.

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Appendix A

MTOP

Montessori Teaching Observation Protocol (MTOP)

Dissertation Project

Texas State University

I. BACKGROUND INFORMATION

Name of teacher _______________________

Class specifics ____

Number of students observed __________ Grade

Level_____________________________

Observer _____________________________ Date of observation

____

Start time ____________________________ End time

____

Observation number __________________________

(First, second, third, fourth)

II. DESCRIPTION OF TEACHING CONTEXT

In the space below please give a brief description of the lesson observed, the classroom setting in which the lesson took place (regular classroom, computer lab, setting arrangements, etc.) Capture, if you can, the defining characteristics of this situation that you believe provide the most important context for understanding what you will describe in greater detail in later sections. Use diagrams if they seem appropriate.

	Never Occurred				Very Common
1. Students are working by themselves or in groups, with little assistance from the teacher.	0	1	2	3	4
2. The math class includes tasks that involve the use of movement and/or manipulatives.	0	1	2	3	4
3. Students do not need to be pushed and reminded to focus in order to continue with what they are working on.	0	1	2	3	4
4. The activities are meant for a student to keep curious and make their own findings.	0	1	2	3	4
5. The teacher is guiding the students rather than feeding them direct information.	0	1	2	3	4
6. Students are relying on descriptions, gesturing, and figures rather than pencil and paper to make realizations.	0	1	2	3	4
7. The class period does not contain a true, direct lesson.	0	1	2	3	4
8. Relationships seem to be personal in this setting.	0	1	2	3	4
9. Dialogue is encouraged and facilitated throughout the room when the teacher deems it necessary.	0	1	2	3	4
10. Assessments are focused on open-ended questions that could result in multiple solutions, rather than concentrating on actual scores.	0	1	2	3	4
11. Students are encouraged to share questions, hints, ideas, and/or progress with other students.	0	1	2	3	4
12. Teacher circulates, observes (to monitor progress), ask questions, and provides necessary help as students work.	0	1	2	3	4

Additional comments you may wish to make about this observation.

Appendix B

TTOP

Traditional Teaching Observation Protocol (TTOP)

Dissertation Project

Texas State University

I. BACKGROUND INFORMATION

Name of teacher ______________________

Class specifics ____

Number of students observed __________ Grade Level___________________________

Observer ___________________________ Date of observation ____________________

Start time __________________________ End time _____________________________

Observation number ________________________
(First, second, third, fourth)

II. DESCRIPTION OF TEACHING CONTEXT

In the space below please give a brief description of the lesson observed, the classroom setting in which the lesson took place (regular classroom, computer lab, setting arrangements, etc.) Capture, if you can, the defining characteristics of this situation that you believe provide the most important context for understanding what you will describe in greater detail in later sections. Use diagrams if they seem appropriate.

Common	Never Occurred				Very
1. For the majority of the instruction time, the teacher directly instructs students.	0	1	2	3	4
2. Students engage in recollection of facts, formulas, or definitions.	0	1	2	3	4
3. Students follow algorithms, whether they understand the reasoning and logic behind them or not.	0	1	2	3	4
4. The majority of questions are directed toward the teacher as the primary source of information rather than peers.	0	1	2	3	4
5. Pencil and paper work is the primary method of showing logic, reasoning, and understanding.	0	1	2	3	4
6. Students are not relying on descriptions, gesturing, objects, or manipulatives.	0	1	2	3	4
7. The class period is focused on one particular topic to cover for that day.	0	1	2	3	4
8. The concept of grading, scoring, and general assessment come up often in the class as a primary means of motivation.	0	1	2	3	4
9. There is some working in pairs and potential for collaboration, but more of a shift toward individual. performance.	0	1	2	3	4
10. Homework is assigned and students are expected to keep up with the workload.	0	1	2	3	4
11. The class consists of exercises of a drill and repetition nature.	0	1	2	3	4
12. Students are not generally given time to discover and conclude their own findings.	0	1	2	3	4

Additional comments you may wish to make about this observation.

Appendix C

CGI Problem Sets

First Set: October

A. Jennifer has ___ dollars. She earns some more money babysitting over the weekend. Now she has ___ dollars. How much money did she earn over the weekend?

B. There are ___ kids in the cafeteria. ___more kids come in for lunch. How many kids are in the cafeteria now?

C. There are ___ children playing in the park. ___ children had to go home. How many children were left playing at the park?

D. There ___ children going to the water park. It costs ___ dollars per person. How much money will it cost for all the children?

E. There are ___ donuts. ___ donuts fit in a box. How many boxes will be needed for all the donuts?

F. There are ___children in P.E. class. The teacher wants to make ___teams with the same number of kids on each team. How many children can she put on each team?

Second Set: February/March

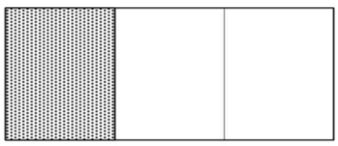
A. ___ children want to share ___ donuts so that everyone gets the same amount. How much can each child have?

B. There are ___ chocolate brownies at Nina's party. ___ children want to share the brownies so that everyone gets to eat the same amount of brownies. How much can each child have?

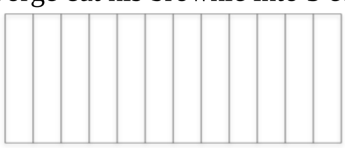
C. Robin went to a party where each person ate ____ of a pizza. If ____ people ate pizza, how many pizzas were there in all so that they each got to eat ____ of a pizza and there were no leftover pieces?

D. Okhee has a snowcone machine. It takes ____ of a cup of ice to make a snowcone. How many snowcones can Okhee make with ____ cups of ice?

E. Jorge and Darren are eating brownies that are the same size.



Jorge cut his brownie into 3 equal pieces and ate 1 piece.



Darren cut his brownie into 12 equal pieces. He wants to eat exactly as much brownie as Jorge.
Color in the amount of brownie Darren should eat, so that his share is equal to Jorge's share.

F. Jane says that if 6 people are sharing 10 cookies each person gets 1 and 2/3 cookies. John says that each person should get 1 and 4/6 cookies. Who is right? Can they both be right?

Appendix D

Interview Templates

GENERAL TEACHER QUESTIONS	GENERAL STUDENTS QUESTIONS
How do you perceive that your role fits into this classroom environment?	How comfortable are you in describing your ideas and explaining thoughts to other students or the teacher?
What types of social cues do you look for in your students each day, and how do established relationships assist with this?	How does your teacher assist you with questions nad problems? Do you like solving problems by yourself?
How does your view or your teaching match/differ from your students' perception?	Do you like solving problems on your own, do you prefer teacher help, or do you like to work in groups?
What do you find is the biggest weakness of the classroom?	What technique do you try when you don't understand how to solve a problem?
What is your interpration of the biggest strength of the classroom?	Do you prefer working with materials or writing your work on paper?
How important is a student's ability to self-regulate and self-motivate in this class?	
How would you describe the role of problem solving in the classroom?	

MONTESSORI-SPECIFIC STUDENT QUESTIONS	TRADITIONAL-SPECIFIC STUDENT QUESTIONS
Can you describe a typical math day at school here?	What is the greatest difference between your math classes this semester compared to last school year?
What do you like about using objects to learn about math?	What do you think about showing your work with pencil and paper?
Do you ever feel like there is too much work to handle in class? Do you ever get stressed out?	Do you feel there is more work to do in this class than before? How do you feel about math overall?
What is your favorite part of math class, overall?	When someone tells you to follow a pattern or a formula, is this more or less helpful than how you wanted to solve the problem?