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I, Richard T Marsicano M.A., hereby submit this original work as part of the requirements for the degree of Doctor of Philosophy in School Psychology.

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Increasing Math Milieu Teaching During Non-Instructional Time via a Graphical Feedback Support Continuum

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Increasing Math Milieu Teaching During Non-Instructional Time via a Graphical Feedback Support Continuum

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Abstract

The current study examined the effect of a varying-intensity, graphical-feedback procedure on increasing the frequency of naturalistic math instruction in preschool classrooms during non-instructional times (transition, meal, free play). Three teachers received professional development that combined goal setting, intervention design, and information on four math-oriented milieu teaching strategies (incidental teaching, time delay, mand model, and model). Teachers then received a high-intensity feedback package associated with a performance criterion and a low-intensity, continued-support feedback package. All teachers demonstrated an increase in the use of math-oriented milieu teaching strategies and positive attention across intervention conditions. In addition, two of the three teachers evidenced generalization of milieu teaching strategies across contexts and content areas. Results are discussed in terms of limitations, future directions, and implications for practice.
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Introduction

There is a critical need for high-quality mathematics instruction and intervention among preschool children in early childhood classroom settings, particularly for children from economically disadvantaged backgrounds (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006; National Mathematics Advisory Panel, 2008). The academic skill deficit of lower performing students not only puts them in an initially precarious position upon school entry; these skill deficits persist over time and are highly predictive of academic performance through high school (Duncan et al., 2007; Stipek, 2001). Moreover, a review of six longitudinal studies focusing on school readiness found that early-math skills are as predictive of later reading achievement as early-reading skills (Duncan et al., 2007). Teachers provide critical math instruction during preschool that help address early math concepts that reduce later educational risk (Miller & Mercer, 1997).

Early Math

Bootstrapping, a concept coined by Stanovich (1986), refers to the reciprocal relationship between reading skills and engagement in reading activities. Due to a complex set developmental and instructional factors, this concept is not sufficient to predict an individual child's reading trajectory; but, does illustrate the differences in the quality and quantity of reading experiences of children with different levels of early-reading skills (Stanovich, 1986). Absent intervention, a child with an early understanding of reading will have a different history with reading comprised of more frequent and positive experiences, as compared to a child that is struggling with reading.

Investigating the relationship between prior math history and achievement, Ma (1997) studied the relationship between students’ math attitudes – in terms of importance, difficulty, and
enjoyment of specific mathematical concepts – and math achievement. Results indicated that a reciprocal relationship existed between the three measures of attitude and achievement and enjoyment directly affected mathematics achievement (Ma, 1997). Fisher et al. (2012) applied Ma’s (1997) theory to preschool students and concluded that initial enjoyment and goal-directed play predicted later mathematical skills and a reciprocal relationship between math interest and skill did exist as early as preschool.

As the quantity and quality of early-math research continues to grow, it is becoming ever more evident that students’ early math skill acquisition, experiences, and interest are related to later math performance (e.g., Aubrey, Dahl, & Godfrey, 2006; Aubrey & Godfrey, 2003; Faulkner, Crossland, & Stiff, 2013; Fisher, Dobbs-Oates, Doctoroff, & Arnold, 2012; Jordan, Kaplan, Locuniak, & Ramineni, 2007; Ma, 1997).

There have been numerous attempts at national levels to promote effective teaching of math skills and concepts and at the center of early math is the construct of number sense (National Council of Teachers of Mathematics, 1989). Number sense was defined as a concept consisting of: (a) number meaning, (b) interrelationships amongst numbers, (c) magnitude, and (d) number operation (NCTM, 1989). Howden (1989), elaborated on the abovementioned definition by saying that number sense “builds on students’ natural insights and convinces them that mathematics makes sense, that it is not just a collection of rules to be applied” (p. 7). Gersten, Jordan, and Flojo (2005) defined number sense as an understanding of numbers themselves and the relationships between different numbers.

The Head Start Bureau (2010) published a framework that takes the concept of number sense, amongst other early math concepts (e.g., geometry), and breaks it down into more tangible
categories. This framework identifies five components integral to the early math curriculum: (a) number concepts and quantities, (b) number relationships and operations, (c) geometry and spatial sense, (d) patterns, and (e) measurement and comparison (Head Start Bureau, 2010). This document further reduces these five areas into tangible skills such as subitizing (identifying the number of objects without counting), number recognition, recognizing simple numerical patterns, counting, and simple number transformations – all specific skills associated with number sense (Berch, 2005).

Although the ultimate goal of mathematics instruction is the ability to adapt learned information to solve novel mathematical problems, early mathematics instruction must first provide the conceptual underpinnings in a manner that facilitates positive learning experiences (Clements & Sarama, 2008; Fisher, et al., 2012; Van de Walle, 2007). Research has shown indirect math-related activities such as math games, as opposed to drill activities, are an effective tool for increasing math skill/concept acquisition and fluency while simultaneously serving as a positive and engaging experience by using the pretext of play (Bjorklund, Hubertz, & Reubens, 2004; LeFevre, Skwarchuk, Smith-Chant, Fast, & Kamawar, 2009; Ramani & Siegler, 2008). Incorporating the Head Start Bureau’s (2010) five elements into the preschool classroom via math-related activities sets the occasion for students to develop number sense and other early math knowledge. These learning opportunities are routinely provided during both structured learning activities (e.g., circle time) and unstructured activities (e.g., free-play time).

**Early Intervention and Multi-Tiered Services**

Response to Intervention (RTI) is a service delivery model that utilizes a tiered approach to proactively identify students at risk for academic and behavioral problems (Barnett, VanDerHeyden, & Witt, 2007). When applied to an early childhood education setting, this
service delivery model is guided by three tenets: (a) strong instructional environments as a foundation for learning, (b) evidence based intervention and support, and (c) data-based decision making that affects the intensity of service delivery (Barnett et al., 2007). These overarching guidelines facilitate the early identification and remediation of needs specific to each student.

Empirically-based prevention and intervention design guided by level of intensity and implementation are hallmarks of the tiered model of service delivery. One method of individualized implementation is matching intervention design to the level of skill development (Daly, Shroder, & Robinson, 2006). The criterion for judging skill level is commonly referred to as the instructional hierarchy and states that when exposed to new material learners generally progress along the continuum of acquisition, fluency, generalization, and adaptation (Haring & Eaton, 1978). Utilization of these two concepts results in an intervention tailored to the skill level of the individual.

Initiating idiosyncratic learning opportunities facilitates the initial understanding (acquisition; fluency) and advanced application (generalization; adaptation) of quantity identification. For example, a preschool student having difficulty with the concept of quantity identification would benefit from naturalistic instruction focusing on this specific concept. A grocery store activity in which the student has to identify different quantities of fruits and vegetables would be more effective in remedying the student’s difficulties than an activity that focused on the addition and subtraction of fruits and vegetables. Though a strong empirical basis for intervention design is obvious, the exceedingly more difficult to quantify aspects of creativity and novelty are equally important (Yopp, 1995).
Milieu Teaching Strategies

Milieu teaching is a broader term for four specific instructional strategies: modeling and mand-modeling, time delay, and incidental teaching. All four of these strategies can be implemented in the natural setting, and are best utilized as interventions when the target child has a language deficit. In fact, Yoder et al. (1995) concluded a milieu teaching package was significantly more effective than a responsive interaction package, a naturalistic instruction method focusing on language modeling and expansions, when a child presented with initially lower levels of expressive and receptive language. This finding suggests that the more purposeful initiations that milieu teaching provides are ideally suited for children in the early stages of language acquisition.

Based on the theory of the acquisition of verbal behavior introduced by Skinner (1957) and methodological advancements described by Hart and Risley (1968), milieu teaching is the use of behaviorally-based instructional practices imbedded within the natural context of the classroom in a conversation-based format (Christensen-Sandfort & Whinnery, 2012). These naturalistic instructional strategies promote the use of functional language by using stimuli that set the occasion for stimuli-related language which, in turn, results in reinforcing consequences (e.g., access to an object) (Hancock & Kaiser, 2006). Milieu teaching strategies have been used to increase the language skills of children with such characteristics as Autism Spectrum Disorder, teratogen exposure, developmental delays, and typically developing children (Bolzani-Dinehart, Kaiser, & Hughes, 2009; Christensen-Sandfort & Whinnery, 2012; Fey et al., 2006; Girolametto, Weitzman, & Greenberg, 2003). Milieu teaching has also been used as a home-based intervention by parents and siblings of children with language delays (Hancock & Kaiser, 2006; Peterson, Carta, & Greenwood, 2005).
Learning new skills requires the learner to attend to the presentation of new material. Research has demonstrated that higher rates of academic engagement are correlated with improved student outcomes (e.g., Cancelli, Harris, Friedman, & Yoshida, 1993; Heward, 1994). Engagement at the preschool level is highly variable and may be highly dependent on the time of day, activity, availability of choice, and the presence of peers and/or adults (Vitiello, Booren, Downer, & Williford, 2012). Allowing the student to determine his or her orientation toward materials and play dynamics (e.g., with peers; in a preferred area of the classroom) via choice-making opportunities can serve to facilitate engagement (Barnett, et al., 2007). In many cases, milieu teaching procedures take advantage of choice by allowing the student to dictate the materials, setting and pace of instruction. The teacher, in turn, can engage in student-perceived play while deliberately implementing milieu teaching strategies that meet the needs of the student.

Another salient argument for the use of naturalistic teaching strategies is high levels of teacher acceptability (Barnett, Carey, & Hall, 1993). Interventions that can be easily incorporated into the daily routine are highly desirable and therefore more likely to be used. Alternatively, Powell, Burchinal, File, and Konto (2008) conducted an eco-behavioral analysis of 12 preschool classrooms with an average of 25 students per class. After 1278 observations of free-play time it was found that teachers were either non-engaged with students or out of range from students during 76% of intervals. This finding suggests there are ample opportunities for increased instruction during the typical school day.

**Modeling, mand-modeling, and time-delay procedures.** Modeling and mand-modeling are strategies that can help facilitate novel language utterances. In modeling, the teacher first establishes joint attention with the student and then presents the student with a
verbal or gestural model related to the child’s engagement (Alpert & Kaiser, 1992; Christensen-Sandfort & Whinnery, 2012). Successful imitation of the model results in praise and access to the desired object. If the child fails to imitate the model, a second model and opportunity to respond are provided. Another incorrect response results in corrective feedback and immediate delivery of the desired object or activity.

The mand-model procedure is used to “encourage generalization and the functional use of an emerging target skill” (Christensen-Sandfort & Whinnery, 2012, p. 3). Once joint attention is established, the teacher presents the child with a functional request. If the child displays the desired behavior (e.g., “I want the truck”) the child is praised and given the object. An unsuccessful attempt results in a second mand for highly engaged students whereas less engaged students are provided with a model (Christensen-Sandfort & Whinnery, 2012). If a student fails to display the desired behavior, the second prompt results in feedback, positive reinforcement, and access to the desired object.

In a study by Toğram and Erbas (2010), the effect of a mand-model training procedure on the vocabulary of three students with developmental disabilities was explored. The researchers reported that target students increased their total use of target words from a baseline rate of 3.3 percent to a post-intervention rate of 73.3 percent (Toğram & Erbas, 2010). Hawkins and Schuster (2007) also used a mand-model procedure while successfully teaching three of four preschool-aged children diagnosed with autism to use the initial /l/ sound within words. While reading a storybook, the researchers intermittently paused and provided a mand (i.e., “What sound is this?), followed by a three second delay when the /l/ sound was featured in a word. Successful utterances were rewarded and unsuccessful attempts were provided with a model.
The time delay procedure, used to elicit the spontaneous use of emergent skills, implements a five-second delay before the initiation of a teacher-directed prompt (Christensen-Sandfort & Whinnery, 2012). This delay allows the child additional opportunity to demonstrate the target response prior to being provided with more intensive support. If the desired response is demonstrated the child receives praise and access to the object; the model or mand-model protocol could follow unsuccessful attempts. Miller, Collins, and Hemmeter (2002) used a naturalistic time delay to facilitate nonverbal communication amongst 3 nonverbal adolescents. Based on past undesired communicative attempts (e.g., tugging on the teacher’s arm to make requests) and a baseline assessment, each student was assigned three target sign words (Miller et al., 2002). At certain times of the day each student was engaged by one of the researchers whose job it was to set the occasion for the target response in blocks of 10 trials. After failing to give the student a ticket for assignment completion, for example, the experimenter presented an attention cue and looked expectantly at the child for four seconds (Miller et al., 2002). After three days of implementation, all students met the signing frequency criterion with one student achieving 100% accuracy across all phases (Miller et al., 2002).

**Incidental teaching.** Incidental teaching (IT) is a naturally arising interaction between an adult and child that transmits information or allows a child to practice a skill (Hart & Risley, 1975). Although the model, mand-model, and time delay procedures can be used in the context of an IT episode, the defining feature of IT is having the environment structured so that this interaction is child-initiated. Hart and Risley (1975) describe the incidental teaching protocol as follows:

1. Establish joint attention
2. Child initiates request
3. Adult decides whether or not to use the occasion for an incidental teaching episode; if yes
4. Decide on desired verbal/gestural response
5. Decide on the type of cue to be used to initiate the episode
   a. Focused attention
   b. Focused attention plus a verbal cue
6. If the child exhibits the target response, grant the request and provide positive attention
7. If the child does not respond to the cue, decide on the level of prompt to be used
   a. Most intensive: full imitation/model
   b. Moderate intensive: partial imitation/model
   c. Least intensive: a request for the desired behavior

IT is an active process that requires the teacher or parent implementing it to make quick, accurate decisions: (a) whether or not to initiate the episode, (b) the desired response, (c) the type of cue used, and (d) the level of prompt to be used during an unsuccessful attempt by the child. The outcomes of the latter two decisions are dependent upon the child’s level of language and the child’s response to previous attempts to elicit the desired response (Hart & Risley, 1975). For example, a child that has had several unsuccessful attempts at demonstrating the desired response might benefit from using a verbal cue along with focused attention and a higher-intensity prompt whereas a student with past successes would be a better candidate for an attention cue and a prompt of a lower intensity.

IT incorporates the elements of strong intervention, which include: (a) numerous opportunities to respond; (b) positive contingencies for fluent and accurate responding; (c) immediate feedback as needed to support learning, all while being implemented in the natural environment (Lentz, Allen, & Ehrhardt, 1996). This instructional strategy transcends the
facilitation of traditional academic engagement by being predicated upon student-directed engagement. IT can be used to address all levels of the instructional hierarchy. For example, a student playing with blocks could: (a) be asked to identify how many blocks he is playing with (a response of counting the blocks and giving the last number would demonstrate acquisition), (b) asked to identify the same quantity of blocks after two more had been added (fluency), (c) have the teacher model generalization by talking about how the addition of two blocks to a quantity of four blocks, for example, results in six blocks, and (d) subtracting three blocks from the same set of blocks and asking for the total (adaptation).

IT episodes are similar to opportunities to respond (i.e., practice opportunities). An opportunity to respond is a teacher-initiated method of instruction that allows a student(s) to practice a skill (Ferkis, Belfiore, and Skinner, 1997). Both IT and opportunities to respond facilitate communication between teacher and student that results in the practice of a new skill. However, IT is predicated upon preexisting student engagement and is necessarily student-initiated.

Hart and Risley (1968) first used an incidental procedure as part of a study in which teacher attention, time in school, and intellectual stimulation did not increase the frequency of complex spontaneous speech. However, making access to preferable materials contingent on complex speech significantly increased a child’s speech. Hart and Risley (1975) later demonstrated that a manualized incidental teaching procedure was effective in increasing desired language in preschoolers. Adults in the Hart and Risley (1975) study were asked to determine if certain naturally occurring adult-child interactions could be used as incidental teaching episodes. These interactions could involve reaching for a toy, helping to put on jacket, pointing at an object, or asking for an object by an incorrect name. After a decision to initiate the procedure
was made, adults were asked to determine the language from the child that would end the instructional episode (e.g., “I want the red truck”) and the cue (e.g., “What do you want?”) that would occasion the child’s verbal behavior. The child was rewarded with praise and when applicable access to the desired object. Over time, the children’s use of spontaneous language increased. Although incidental teaching can be used in a wide variety of domains, the majority of research has focused on incidental teaching’s effect on language development and acquisition with children with Autism (Charlop-Christy & Carpenter, 2000; McGee, Morrier, & Daly, 1999).

**Milieu Teaching Strategies in Early Math Skill Acquisition**

The majority of milieu teaching is used to facilitate functional language development. Hart and Risley (1992; 1995) cemented the idea that there is a direct relationship between the quantity and quality of early language experiences and a child’s later language development. Applying this finding to a content specific language would suggest that children exposed to such language would develop vocabulary associated with the content.

Kilbanoff et al. (2006) conducted the first study to take a content-specific approach by using a direct measure of math-talk frequency. The direct measurement of math talk allowed the researchers to measure both incidental and planned mathematics instruction (Kilbanoff et al., 2006). Twenty-six observations lasting between 150 and 180 minutes resulted in approximately one hour of recorded teacher speech. Circle time was recorded in each observation. Nine distinct types of mathematic input were recorded: (a) counting, (b) cardinality, (c) equivalence, (d) nonequivalence, (e) number symbols, (f) conventional nominative, (g) ordering, (h) calculation, and (i) place holding. Researchers also administered a pre-test and post-test consisting of 15 multiple choice questions to evaluate any mathematical gains in the aforementioned math areas.
Kilbanoff et al. (2006) reported three substantial findings: (a) students had SES-dependent variance in mathematical knowledge at four years of age, (b) the amount of math talk in each classroom was highly variable (1-104 instance of input) yet independent of student SES status, and (c) the amount of math talk was significantly related to student math knowledge at year’s end. Thus, there is a significant need and positive effect of increased math talk in the preschool classroom.

**Performance Feedback**

Performance feedback involves assessing a target person’s behavior and comparing it to an agreed upon criterion. In the school setting, providing teachers with performance feedback has become the standard (Noell, Witt, Gilbertson, Ranier, & Freeland, 1997; Noell et al., 2000, 2005; Sanetti & Kratochwill, 2008). Although performance feedback can take different forms, feedback is most often administered verbally and/or graphically. However, graphical feedback is directly linked to school-related data-based decisions (Barnett et al., 2007; Solomon, Klein, & Politylo, 2012).

In the classroom, performance feedback has been shown to increase teacher adherence to intervention procedures (Gilbertson, Witt, Singletary, & VanDerHeyden, 2007; Noell et al., 1997, 2000, 2005; Sanetti & Kratochwill, 2008) and targeted instructional and managerial behaviors (Leach & Conto, 1999). Teachers receiving performance feedback implemented significantly higher levels of academic intervention adherence when compared to teachers only discussing intervention adherence (Noell et al., 2000). An evaluation of three performance feedback methods demonstrated a method incorporating graphing intervention implementation and student behavior was superior to both brief structured interview and interview plus commitment emphasis conditions (Noell et al., 2005).
Solomon et al. (2012) conducted a meta-analysis investigating how setting, target behavior, population, and latency, contributed to the effectiveness of performance feedback. Performance feedback was defined as data-based feedback presented verbally or verbally and graphically, as operationalized by Noell et al. (2005). Inclusion criteria did not address grade level: Studies with preschool-aged students to high-school aged students were part of this analysis. In each of the 36 studies the primary target for change was teacher behavior. The researchers concluded that performance feedback was effective across all contexts, latencies, and types of interventions.

Further exploration of their results revealed less conclusive findings. Delivering feedback within 24 hours of observation did not result in a statistically significant increase in effectiveness as compared to feedback delivered a full week after observation. However, in an earlier review by Scheeler, Ruhl, and McAfee (2004), immediate performance feedback was significantly more effective than delayed feedback. These conflicting results warrant further investigation.

Casey and McWilliam (2008) used a graphical feedback condition to increase teachers’ use of IT. Twenty-one teachers attended a training procedure that defined IT, discussed its purpose, and described ways in which it could be used during naturally occurring interactions. After the training, teachers were asked to implement the IT procedure in their classroom while observers recorded the frequency of implementation. Two minutes prior to each observation session, the teacher would be shown a graph depicting the previous observation’s data. Teachers were asked to increase their use of IT during the next session regardless of their level of performance. The graphical feedback procedure increased the teachers’ use of IT. In addition, higher levels of IT were found during post-intervention sessions.
In addition to the direct benefits of enhancing mathematical instruction, resulting in an increase of math practice for all students in participating classes, the purpose of this study is to add to the body of literature in four ways. First, this study will expand the use of the incidental-teaching-only criterion used by Casey and McWilliam (2008) by also including the use of the mand, mand-model, and time delay procedures. Second, feedback will be provided on both the adherence to an intervention script (i.e., the how) and the frequency in which math milieu teaching strategies are provided (i.e., the how much). Third, this study will begin to explore the range of effectiveness in implementing a continuum of feedback support by providing teachers with low-support and, if warranted, more intensive feedback support. Fourth, indirect effects of increased milieu teaching use, such as classroom management and positive attention, will be assessed.

**Research Questions:**

The four research questions to be examined in this study are:

1. Is graphical feedback effective in increasing the frequency of math-oriented milieu teaching strategies?
2. What intensity of feedback is effective in increasing the frequency of math-oriented milieu teaching strategies?
3. How does in an increase in the frequency of math-oriented milieu teaching strategies affect other classroom variables?
4. Will teachers trained in the use of math-oriented milieu teaching strategies evidence generalization?
Method

Participants and Setting

The setting for this study was a Head Start agency in the Midwest. A flyer (see Appendix A) was distributed agency-wide to inform teachers of this study. Informed consent was obtained from all participating teachers (see Appendix B). The study was explained to participating teachers, and all other participants (e.g., research assistants) in accordance with an information script (see Appendix C). This information script and all subsequent materials and procedures were approved by the Institutional Review Board of the University of Cincinnati.

**Teacher selection.** Four classrooms were observed in order to determine which classrooms were in most need of intervention. Three teachers, two of which were in the same classroom, participated in the intervention phase in this study; one teacher did not reach intervention phase due to an extended absence. Given that all classrooms showed a near-zero frequency of naturally occurring math instruction, it was determined that all of the participating classrooms were in need of support.

**Research assistants.** All research assistants were University of Cincinnati School Psychology graduate students. Each assistant was trained in the use of the observation code (see Appendix D), participated in a co-observation(s) with the Principle Investigator and earned a score of 100% on the observation code quiz (see Appendix E). Research assistants were responsible for conducting a portion of the direct observations, inter-observer agreement observations, and providing performance feedback when required. Research assistants did not participate in the professional development or teacher fluency phases (i.e., high-support condition) of this study.
Materials

Materials used to develop interventions that facilitated an increase in milieu teaching were provided by the Principle Investigator. A menu of example interventions (see Appendix F) was provided to participating teachers during the professional development phase of the study. All teachers elected to use the interventions described in the menu. The materials purchased for the missing toy intervention were colored index cards and a jester hat (see intervention procedures for a full explanation of each intervention). The only materials purchased for the shape sticks intervention and the something’s fishy interventions were colored toothpicks and goldfish snacks, respectively. All intervention materials purchased by the Principle Investigator were donated to the participating Head Start center.

Performance feedback graphs used in the graphical feedback condition were created in Microsoft Excel. Each teacher was shown a graph that depicted the frequency of Math Instructional Episodes and intervention adherence (see below for definitions; see Appendix G for sample graph). Intervention adherence data points, and the relevant y-axis values, were drawn by hand.

Observation Method

All observations took place Monday through Thursday and occurred during transition, lunch, and free-play time. Transition time began when the teacher announced the transition (usually 10 minutes prior to the actual transition) and ended when the transition process began. Lunch and snack time began when all students were at their assigned tables and had received their food and ended when the teachers signaled it was time to clean up. Free-choice time began when all students had transitioned from circle time to the free-play area and ended when a transition signal was given.
A stimulus change was required for multiple instances of the same milieu teaching strategy to be recorded. For example, when pointing to a card containing five triangles, multiple prompts asking the student to identify the number of triangles only resulted in one, in this case Math Mand Model, instructional episode. However, asking the student to identify the number of shapes and then to identify the shape name would result in two, in this case Math Mand Model, instructional episodes.

Observation sessions did not exceed 35 minutes. Although the time of each observation session was dependent on each participating teacher’s class schedule, one thirty-minute observation could span free-choice time, transition, and lunch. The observation code allowed for one observation to occur across multiple contexts since a change in activities is recorded on the code. Research assistants and/or the principle investigator conducted all observation sessions.

**Social validity.** Social validity data were collected from two of the three teachers that reached the intervention phase. A survey (see Appendix H) was given to each teacher upon completion of data collection. Questions were answered on a Likert-type scale with answers ranging from 1 to 5, where 1 represented strongly disagree and 5 represented strongly agree.

**Observation Code**

The observation code (see Appendix D) was used to record the frequency of 12 dependent variables. The dependent variables were recorded using a frequency-per-minute recording procedure. Table 1 describes each variable, a brief definition, and the abbreviations for the variable.
Table 1  

Dependent Variable Definitions

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Abbreviation</th>
<th>Definition</th>
<th>Recording Method</th>
<th>Empirical Basis</th>
</tr>
</thead>
</table>
| Math Incidental Teaching Episode | MITE         | An interaction between a teacher and child that: (a) occurred within the context of the previous or existing occasion of the child, (b) contained a child-initiated request, (c) contains an adult-initiated cue (i.e., attention or attention + prompt) for the desired math behavior, (d) a response by the child, and either (e) the teacher granting the request and praise if the child exhibited the target response or (f) a second prompt (i.e., full imitation and model; partial imitation and model, or a request for the target response) plus the teacher granting the request and praise. | Freq/min          | • Casey & McWilliam (2008)  
  • Hart & Risley (1975) |
| Non-math incidental teaching episode | NMITE        | An NMITE followed the same protocol as a MITE except the desired response is not math related.                                                                                                                                                                                                                                           | Freq/min          | • Casey & McWilliam (2008)  
  • Hart & Risley (1975) |
| Math model episode               | MM           | An interaction between a teacher and child that: (a) occurred within the context of the previous or existing occasion of the child, (b) contained a math verbal or gestural model related to the child’s engagement (e.g., “Tell me you want the truck with more people in it.”), (c) access to the desired object and praise when the model is successfully imitated, or (d) a second model with access to the desired object and praise when the model was successfully imitated or feedback, praise, and the immediate delivery of the desired object after a second unsuccessful attempt. | Freq/min          | • Alpert & Kaiser (1992)  
  • Christensen-Sandfort & Whinnery (2012) |
| Non-math model episode           | NMM          | An NMM followed the same protocol as a MM except the model is not math related.                                                                                                                                                                                                                                                         | Freq/min          | • Alpert & Kaiser (1992)   |
Math mand-model episode MMM
An interaction between a teacher and child that: (a) occurred within the context of the previous or existing occasion of the child, (b) contained a verbal mand (e.g., “Tell me what you want.”) requiring a math-related response, and either (c) access to the desired object and praise if the target response (e.g., “I want the bin with three toys in it”) or (d) a second math-related mand a second model with access to the desired object and praise when the model was successfully imitated or feedback, praise, and the immediate delivery of the desired object after a second unsuccessful attempt.

Non-math mand-model episode NMMM
A NMMM followed the same protocol as a MMM except the mand does not require a math-related response.

Math time-delay episode MTD
An interaction between a teacher and a child in which the teacher responded to a child by pausing for 3-5 seconds prior to a mand or mand-model procedure requiring a math-related answer. An incorrect response was followed by the mand-model procedure, if engagement is high, or the model procedure, if engagement is low or if the student is unlikely to know the response. A MTD was recorded whether or not a model or mand-model procedure is also used. An interaction that used a mand or mand-model procedure after a time-delay will be coded as a time-delay episode, math or non-math, and a mand or mand-model episode, math or non-math.

Non-math time-delay episode NMTD
A NMTD followed the same protocol as a MTD except the target response is not math related.
<table>
<thead>
<tr>
<th>Measure</th>
<th>Code</th>
<th>Description</th>
<th>Unit</th>
<th>Source(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academically oriented group opportunity to respond</td>
<td>GOR</td>
<td>A teacher-initiated method of instruction that occurred when a group of students were prompted for an academic behavior that provided students with an opportunity to respond to a teacher’s prompt (“What is 2 plus 2?”) with a verbal (saying “4”) and/or nonverbal (holding up 4 fingers) response.</td>
<td>Freq/min</td>
<td>Christensen-Sandfort &amp; Whinnery (2012)</td>
</tr>
<tr>
<td>Positive Attention</td>
<td>PA</td>
<td>A bout of positive attention occurred when a teacher provided verbal, tangible, or physical-contact reinforcement to a child. PA provided during a MITE or NMITE will be recorded as an instance of positive attention.</td>
<td>Freq/min</td>
<td>Ferkis et al. (1997)</td>
</tr>
<tr>
<td>Teacher managerial behavior</td>
<td>TMB</td>
<td>Teacher managerial behavior was disaggregated into positive managerial positive and negative managerial behavior. A teacher managerial positive occurrence was recorded when a teacher delivered a verbal reminder to a child engaged in an inappropriate behavior using a firm yet pleasant tone of voice. This included getting the child’s or group’s attention by making eye contact, saying the child’s name, or using a signal and providing one of the following: a replacement behavior, an explanation, practice, or a choice. A teacher managerial negative behavior was recorded when a teacher was engaged in negative scanning of the classroom or group and delivered a verbal reprimand (formal scolding) to a child engaged in an inappropriate behavior, there was not a verbal explanation of what the child did that was inappropriate, and no replacement behavior was provided.</td>
<td>Freq/min</td>
<td>Sutherland, Alder &amp; Gunter (2003)</td>
</tr>
<tr>
<td>Intervention adherence</td>
<td>IA</td>
<td>The amount of intervention-oriented behavior, recorded as the percentage of script steps completed, displayed by an interventionist.</td>
<td>Percentage of script steps completed</td>
<td>Nichols &amp; Barnett (2004)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Boat et al. (2009)</td>
</tr>
</tbody>
</table>

* [Intervention adherence](#)
Math Instructional Episodes

MIE was calculated after each observation by taking the total frequency of MITE, MM, MMM, and MT.

Freq/min

Non-math Instructional Episodes

NMIE was calculated by taking the total frequency of NMITE, NMM, NMMM, and NMTD.

* Variables were graphed and given to teachers as part of the teacher fluency and performance feedback conditions

** Dependent Variables**

All dependent variable definitions were empirically derived. Milieu teaching strategy variables (i.e., MITE, NMITE, MM, NMM, MMM, NMMM, MTD, and NMTD) were based on operational definitions used by Casey and McWilliam (2008) and Hart and Risley (1975) in their respective research. Variables that measured indirect benefits of using milieu teaching strategies (i.e., GOR, PA, and TMB) were taken from the Instruction and Caring Contacts (ICC, Nichols & Barnett, 2004) preschool observation code. The ICC has been used to measure interactions between students and teacher that teach students specific skills and/or reinforce positive and appropriate student behavior. The ICC was developed for use in the preschool classroom and has been vetted for this purpose (Boat et al., 2009; Nichols & Barnett, 2004).

**Math incidental teaching episode (MITE).** Based on the operational definitions used by Casey and McWilliam (2008) and Hart and Risley (1975), a math incidental teaching episode (MITE) was defined as an interaction between a teacher and child that: (a) occurs within the context of the previous or existing occasion of the child, (b) contains a child-initiated request, (c) contains an adult-initiated cue (i.e., attention or attention + prompt) for the desired math
behavior, (d) a response by the child, and either (e) the teacher granting the request and praise if the child exhibits the target response or (f) a second prompt (i.e., full imitation and model; partial imitation and model, or a request for the target response) plus the teacher granting the request and praise. An example of a MITE can be found in the Something’s Fishy example in Appendix I.

**Non-math incidental teaching episode (NMITE).** Based on the operational definitions used by Casey and McWilliam (2008) and Hart and Risley (1975), a NMITE followed the same protocol as a MITE except the desired response was not math related.

**Math model episode (MM).** Based on the operational definitions used by Alpert and Kaiser (1992) and Christensen-Sandfort and Whinnery (2012), a math model (MM) was defined as an interaction between a teacher and child that: (a) occurred within the context of the previous or existing occasion of the child, (b) contained a math verbal or gestural model related to the child’s engagement (e.g., “Tell me you want the truck with more people in it.”), (c) granted access to the desired object and praise when the model was successfully imitated, or (d) contained a second model with access to the desired object and praise when the model was successfully imitated or feedback, praise, and the immediate delivery of the desired object after a second unsuccessful attempt.

**Non-math model episode (NMM).** Based on the operational definitions used by Alpert and Kaiser (1992) and Christensen-Sandfort & Whinnery (2012), a NMM followed the same protocol as a MM except the model was not math related.

**Math mand-model episode (MMM).** Based on the operational definitions used by Alpert and Kaiser (1992) and Christensen-Sandfort and Whinnery (2012), a math mand-model episode (MMM) was an interaction between a teacher and child that: (a) occurred within the
context of the previous or existing occasion of the child, (b) contained a verbal mand (e.g., “Tell me what you want.”) that required a math-related response, and either (c) access to the desired object and praise if the target response was given (e.g., “I want the bin with three toys in it”) or (d) a second math-related mand a second model with access to the desired object and praise when the model was successfully imitated or feedback, praise, and the immediate delivery of the desired object after a second unsuccessful attempt. A math mand followed by a math model without a stimulus change was recorded as a MMM, as opposed to a MMM and a MM.

Non-math mand-model episode (NMMM). Based on the operational definitions used by Alpert and Kaiser (1992) and Christensen-Sandfort & Whinnery (2012), a NMMM followed the same protocol as a MMM except the mand did not require a math-related response (e.g., “I want the red one.”). A non-math mand followed by a non-math model without a stimulus change was recorded as a MMM, as opposed to a MMM and a MM.

Math time-delay episode (MTD). Based on the operational definitions used by Alpert and Kaiser (1992) and Christensen-Sandfort and Whinnery (2012), a MTD occurred when a teacher responded to a child by pausing for 3-5 seconds prior to a mand or mand-model procedure that required a math-related answer. An incorrect response was followed by the mand-model procedure, if engagement was high, or the model procedure, if engagement was low or if the student was unlikely to know the response. A MTD was recorded whether or not a model or mand-model procedure was also used. An interaction that used a mand or mand-model procedure after a time-delay was coded as a time-delay episode, math or non-math, and a mand or mand-model episode, math or non-math.
**Non-math time-delay episode (NMTD).** Based on the operational definitions used by Alpert and Kaiser (1992) and Christensen-Sandfort & Whinnery (2012), a NMTD followed the same protocol as a MTD except the target response was not math related.

**Math instructional episodes (MIE).** This variable, along with intervention adherence, was used during the graphical feedback procedure. MIE was a summative variable that represented the total frequency of math instructional episodes (i.e., MITE+MMM+MM+MTD) during any one observation.

**Non-math instructional episodes (NMIE).** NMIE was a summative variable that represented the total frequency of non-math instructional episodes (i.e., NMITE+MMM+MM+MTD) during any one observation.

**Academically oriented group opportunity to respond (GOR).** A group opportunity to respond (GOR) was defined as a teacher-initiated method of instruction that occurred when a group of students were prompted for an academic behavior as defined by Based on Ferkis et al. (1997) and Sutherland, Alder and Gunter (2003). A GOR provided students with an opportunity to respond to a teacher’s prompt (“What is 2 plus 2?”) with a verbal (saying “4”) and/or nonverbal (holding up 4 fingers) response.

**Positive attention (PA).** A bout of positive attention was recorded when a teacher provided verbal, tangible, or physical-contact reinforcement to a child as defined by Nichols and Barnett (2004). In addition to instances of PA that occurred independent of any teaching strategy, a bout of PA was also recorded when provided within the context of a milieu teaching strategy (e.g., the teacher says, “Great job” after the child requests the appropriate object during an incidental teaching episode).
**Teacher managerial behavior (TMB).** Teacher managerial behavior was disaggregated into positive managerial positive and teacher managerial negative behavior as defined by Nichols and Barnett (2004). A teacher managerial positive occurrence was recorded when a teacher delivered a verbal reminder to a child engaged in an inappropriate behavior using a firm yet pleasant tone of voice. This included getting the child’s or group’s attention by making eye contact, saying the child’s name, or using a signal and providing one of the following: a replacement behavior, an explanation, practice, or a choice. A teacher managerial negative behavior was recorded when a teacher was engaged in negative scanning of the classroom or group and delivered a verbal reprimand (formal scolding) to a child engaged in an inappropriate behavior, there was not a verbal explanation of what the child did that was inappropriate, and no replacement behavior was provided.

**Intervention adherence (IA).** Based on Meichenbaum and Turk (1987), intervention adherence was defined as the amount of intervention-oriented behavior displayed by an interventionist. A contextualized intervention plan, or script, was used as the criterion for determining IA (Barnett et al., 2007). A separate script was developed for each of the three interventions (see below). Adherence data were recorded during all post-baseline observation sessions. IA was recorded as the percentage of script steps completed during an observation session.

**Feedback Session Criteria**

After each observation requiring feedback, teachers were shown a graph depicting the total frequency of MIE and intervention adherence (see Appendix J). If a teacher failed to reach the target MIE frequency (see below), the data illustrated in the graph were used to clarify the discrepancy between the observed frequency of instruction and the goal, and for possibly
providing suggestions for improvement. For example, a teacher with a low frequency of math instructional episodes and a low frequency of intervention adherence would have been shown a graph depicting the variables and be told that increasing the use of the latter is a possible area for improvement.

**Intervention Procedures**

During the professional development phase (described below), each teacher was given the opportunity to design three interventions with the Principle Investigator or use the interventions already designed prior to this study. All three teachers that reached the intervention phases chose to use the interventions designed by the Principle Investigator. Each of the three interventions corresponded with a specific context and were implemented throughout all post-professional-development phases. All of the interventions were designed to incorporate the opportunities to initiate MMM, MM, and/or MTD. Additionally, an opportunity to provide PA was imbedded into each intervention. Only the mealtime intervention contained an opportunity to provide MITE. All mathematical concepts included in the interventions were derived from the Head Start Learning Framework (Head Start Bureau, 2010).

**Missing toy.** This intervention was used during free-play time (see Appendix K). Along with PA, opportunities to initiate MMM, MM, and/or MTD were imbedded into this intervention. This intervention directed the teacher to approach a student at play and playfully take one of the toys he or she was playing with. The teacher would place this stolen toy on one of two corresponding index cards and the toy not in use on the other index card. Each pair of index cards depicted a mathematical concept (e.g., quantity discrimination; size; shapes). The student was then asked to identify the correct mathematical concept. A correct answer resulted in the
student given access to their toy and verbal praise. An incorrect answer resulted in the teacher supplying a more intensive prompt.

**Shape sticks.** This intervention was used during transition time (see Appendix L). Along with PA, opportunities to initiate MMM, MM, and/or MTD were imbedded into this intervention. This intervention directed the teacher to approach a student during transition time and engage the student in a discussion about shapes. Once engagement was established, the teacher would use colored toothpicks to make a shape. A correct answer resulted in the student being allowed to clean up their materials and take a book to read on the carpet and verbal praise. An incorrect answer resulted in the teacher supplying a more intensive prompt.

**Something’s fishy.** This intervention was used during meal time (see Appendix I). Along with PA, opportunities to initiate MITE, MMM, MM, and/or MTD were imbedded into this intervention. Teachers were asked to initiate a conversation, individually or class-wide, about fish. Once engagement was established, the teacher would ask the student how many goldfish snacks he or she wanted. Teachers would then give the student the incorrect amount of fish. A student verbalizing that the amount was incorrect resulted in the student getting the appropriate amount of fish in accordance with the original request and verbal praise. An incorrect response resulted in the teacher supplying a more intensive prompt.

**Reliability**

**Intervention adherence.** Intervention adherence data were collected during 100% of interventions observation sessions and across all three contexts (i.e., free play; meal; transition). Research assistants and the Principle Investigator were responsible for collecting intervention data. Observers recorded the number of script steps completed on intervention checklists (see Appendices M, N, and O). Overall intervention adherence during the high-support and low-
support conditions was 85.75% and 98.89%, respectively. Disaggregated by activity, intervention adherence during free play, transition, and meal were 94%, 96%, and 96%, respectively. Table 2 summarizes all intervention adherence data.

Table 2

Summary of Intervention Adherence

<table>
<thead>
<tr>
<th>Percentage of Script Steps Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Support</td>
</tr>
<tr>
<td>Low Support</td>
</tr>
<tr>
<td>Free play</td>
</tr>
<tr>
<td>Transition</td>
</tr>
<tr>
<td>Meal</td>
</tr>
</tbody>
</table>

Note. Adherence data were collected during 100% of intervention observations.

Inter-observer agreement. Table 3 shows Inter-observer agreement (IOA). IOA was obtained during 26% of all observation sessions (20% of observation sessions minimum, Kennedy, 2005). Sixty-six percent of IOA sessions occurred during the intervention phase. IOA was collected during baseline, high support, and low support conditions, and was collected in all classrooms that reached the intervention phase. IOA was calculated by dividing the smaller frequency of occurrence by the larger frequency of occurrence (27/29 = IOA of 93%). Data indicated a high overall IOA with a mean of 97.49% and a high math-variable IOA with a mean of 96.28%. IOA was also high across free play, transition, and meal times, with means of 99.01%, 94.31%, and 95.23%, respectively.
Table 3

*Inter-Observer Agreement by Context*

<table>
<thead>
<tr>
<th></th>
<th>Mean (%)</th>
<th>Range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free play</td>
<td>99.01</td>
<td>97.96 - 100</td>
</tr>
<tr>
<td>Transition</td>
<td>94.31</td>
<td>82.67 – 100</td>
</tr>
<tr>
<td>Meal</td>
<td>95.23</td>
<td>91.67 - 99.05</td>
</tr>
<tr>
<td>Total Math</td>
<td>96.28</td>
<td>92.06 - 100</td>
</tr>
<tr>
<td>Total</td>
<td>97.49</td>
<td>92.81 - 100</td>
</tr>
</tbody>
</table>

*Note.* Co-observations were conducted during 26% of total observation sessions; sixty-six percent of co-observations were conducted during the intervention phase.

Table 4 shows inter-observer agreement data separated by variable. High rates of IOA were evident across all variables. In addition, the variables taken from the ICC also have prior reliability estimates based on 99 observations in 22 classrooms (Nichols & Barnett, 2004).
## Table 4

*Inter-Observer Agreement by Variable*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (%)</th>
<th>Range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Incidental Teaching</td>
<td>98.89</td>
<td>94.74-100</td>
</tr>
<tr>
<td>Non-math Incidental Teaching</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Math Mand</td>
<td>97.73</td>
<td>75-100</td>
</tr>
<tr>
<td>Non-math Mand</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Math Mand Model</td>
<td>95.65</td>
<td>80-100</td>
</tr>
<tr>
<td>Non-math Mand Model</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Math Time Delay</td>
<td>89.17</td>
<td>50-100</td>
</tr>
<tr>
<td>Non-math Time Delay</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Academically Oriented Group</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Opportunity to Respond</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Positive Attention</td>
<td>98.25</td>
<td>85.7-100</td>
</tr>
<tr>
<td>Teacher Managerial Behavior</td>
<td>92.93</td>
<td>33.33-100</td>
</tr>
</tbody>
</table>

### Goal Setting

Goals for the use of math instruction episodes were based on each teacher’s baseline data. The mean for all teachers baseline MIE was .074 (SD= .101) episodes per minute. Based on the near zero frequency of baseline MIE, the teachers and the PI set the initial teacher fluency MIE goal as 0.8 MIE per minute. Each goal was set by the PI and teacher during the professional development condition.

The goal for intervention adherence was 100%; however, the teacher fluency phase was the initial implementation of each intervention. Therefore, intervention steps that were not
demonstrated during this initial intervention condition were immediately discussed and remedied.

**Research Design**

A combined delayed-multiple-baseline and changing-criterion single-case design was used in this study to assess changes in teacher variables (Kennedy, 2005). Combined designs are commonly used design for single-subject educational research. Following baseline in the first classroom, this design systematically but briefly delayed the onset of data collection across classrooms in order to demonstrate experimental control of the intervention and increases in target variables. Individual teacher data were graphed and separated by the type of dependent variable.

**Experimental Conditions**

**Baseline.** In order to collect data representative of the classroom, and in full compliance with IRB approved procedures, teachers were not informed about the math aspect of this study until after all baseline data were collected. The observation code and procedures previously described were used during this phase. Six data points were collected in each class – two from each of the three contexts. Intervention adherence data were not collected during the baseline phase.

**Professional development on math milieu teaching strategies.** Upon conclusion of the baseline phase, a professional development session took place with each individual teacher from the participating classrooms. Each session, carried out by the Principle Investigator, lasted from 45 minutes to 75 minutes. Sessions were scheduled at times convenient for the teachers. The goals for the each professional development session were to: (a) review milieu teaching strategies and early math topics via a PowerPoint presentation, (b) review the teacher’s baseline
Teacher fluency condition. A teacher fluency condition was introduced once the intervention consultation was completed (Noell et al., 2005). Analogous to the high support condition described below, this condition incorporated immediate graphical and verbal feedback on the number of intervention steps demonstrated and on the total frequency of MIE. Intervention steps that were missed during this phase resulted in the PI immediately reminding the teacher of the step and asking the teacher to complete the step. Once a teacher reached three consecutive observation points above the goal line, the low support feedback condition was implemented.

Performance feedback package. Participating teachers proceeded to the performance feedback condition upon completion of the teacher fluency condition. During this condition all teachers received graphical and verbal feedback on intervention adherence and the frequency of math instructional episodes. Feedback was provided to teachers verbally and graphically in accordance with the graphical feedback script (see Appendix J).

Based on the conflicting findings regarding optimal feedback performance characteristics (i.e., Scheeler et al, 2004; Solomon et al., 2012), and in order to help elucidate the least intrusive level of effective intervention support, as is outlined in the conceptual underpinnings of multi-tiered services, each classroom began by receiving the low support condition (Barnett et al., 2007; Boat et al., 2009). Using the three-point decision rule, if the last three intervention adherence or frequency count of MIE data points evidenced an inadequate progress toward the goal, the participating classroom would receive the high-support condition (i.e., immediate feedback faded to 24 hour delayed feedback; Riley-Tillman & Burns, 2009). If initiated, a
teacher would have remained in the high-support condition until intervention adherence was once again at 100% and the frequency of math instructional episodes was at or above the goal.

**Low support condition.** This condition provided teachers with weekly (i.e., after 3 observations) graphical and verbal performance feedback on intervention adherence and the frequency count of math instructional episodes. If teachers were unable to reach the MIE goal, the high support condition would have been initiated.

**High support condition.** This support condition was designed to provide feedback in the same manner as described above; however, feedback would have been given with higher frequency and immediacy. This condition was designed for teachers to receive feedback on the pertinent variables immediately following the observation session. Once intervention adherence was at 100% and the frequency of math instructional episodes was at or above the goal line, the frequency of feedback would have been faded so that the participating teacher would have received one session of 24 hour delayed feedback (i.e., graphical and verbal feedback prior to the next observation session). If both intervention adherence and the frequency of math instructional episodes remained at 100% and at or above the goal line, respectively, the teacher would have again received the low-support condition. A failure to maintain expected levels of adherence and math instruction would have resulted in the teacher continuing to receive immediate feedback.

Since high levels of intervention adherence (e.g., 100% of steps completed) and math instructional episodes (at or above the goal decided on by the Principle Investigator and teachers) were maintained throughout the duration of this study, each teacher remained in the low support condition until conclusion of the study.
Results

The four research questions examined in this study were: (a) is graphical feedback effective in increasing the frequency of math-oriented milieu teaching strategies, (b) what intensity of feedback is effective in increasing the frequency of math-oriented milieu teaching strategies, (c) how does an increase in the frequency of math-oriented milieu teaching strategies affect other classroom variables, and (d) will teachers trained in the use of math-oriented milieu teaching strategies evidence generalization?

Is Graphical Feedback Effective in Increasing the Frequency of Math-Oriented Milieu Teaching Strategies?

Analyses of the data suggested that graphical performance feedback was effective in increasing the frequency of math-oriented milieu teaching strategies in all three contexts (i.e., free play; meal; transition). This research question was explored by examining the total frequency of math instructional episodes for each teacher and the frequency of math instructional episodes displayed by each teacher in each separate context. Further analyses were conducted to determine how often each of the four math-oriented milieu teaching strategies – incidental teaching, mand model, modeling, and time delay – was used.

Total frequency of math instructional episodes. Math instructional episodes was a summative variable that represented the total frequency of math instructional episodes (i.e., MITE+MMM+MM+MTD) during any one observation. Figure 1 depicts the total frequency of MIE in classes 1, 2, and 3 across all three contexts (i.e., free play, transition, and meal). Visual analyses for all three teachers indicated an increase in MIE across phases. All three teachers displayed near-zero frequencies of MIE prior to intervention implementation.
Visual analyses revealed that each teacher demonstrated an increase in level from the baseline to high-support conditions and again from the high-support condition to the low-support condition. Teachers 1 and 2 evidenced highly variable data in the low-support condition. The data for teacher 3, though variable, suggests an overall increasing trend from the beginning of the low-support condition to its end.

Teacher 1 evidenced a low frequency of math instructional episodes ($M = .074; SD = .120$) during baseline. MIE increased during the high-support condition ($M = 1.67; SD = 1.51$) and increased further during the low-support condition ($M = 2.24; SD = 1.74$). The total intervention (i.e., high support + low support) frequency of MIE for this teacher was 2.05 ($SD = 1.60$).

Teacher 1 reached the goals of 0.8 MIE/minute during the high-support phase and 1.0 MIE/minute during the low-support condition during every observation session. Means and standard deviations are displayed in Table 5.
Teacher 2 evidenced a low frequency of math instructional episodes ($M= .05; SD= .07$) during baseline. MIE increased during the high-support condition ($M= 1.72; SD= .35$) and increased further during the low-support condition ($M= 2.78; SD= 1.31$). The total intervention frequency of MIE for this teacher was $2.51 (SD= 1.22)$. Teacher 2 reached the goals of 0.8 MIE/minute during the high-support phase and 1.5 MIE/minute during the low-support condition during every observation session.

Teacher 3 evidenced a low frequency of math instructional episodes ($M= .10; SD= .12$) during baseline. MIE increased during the high-support condition ($M= 1.29; SD= .77$) and increased further during the low-support condition ($M= 3.62; SD= 1.50$). The total intervention frequency of MIE in this class was $3.04 (SD= 1.69)$. Teacher 3 reached the goals of 0.8 MIE/minute during the high-support phase and 2.0 MIE/minute during the low-support condition during every observation session.
Table 5

*Total Math Instructional Episodes Means (SD)*

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>High Support</th>
<th>Low support</th>
<th>Intervention Total(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher 1</td>
<td>.07 (.12)</td>
<td>1.67 (1.51)</td>
<td>2.24 (1.74)</td>
<td>2.05 (1.59)</td>
</tr>
<tr>
<td>Teacher 2</td>
<td>.05 (.07)</td>
<td>1.72 (.35)</td>
<td>2.78 (1.31)</td>
<td>2.51 (1.22)</td>
</tr>
<tr>
<td>Teacher 3</td>
<td>.10 (.12)</td>
<td>1.77 (.08)</td>
<td>3.62 (1.50)</td>
<td>3.16 (1.53)</td>
</tr>
<tr>
<td>Total</td>
<td>.07 (.10)</td>
<td>1.72 (.77)</td>
<td>2.96 (1.54)</td>
<td>2.62 (1.47)</td>
</tr>
</tbody>
</table>

\(^a\)Combination of high support and low support

**Frequency of math instructional episodes displayed by each teacher in each context.**

Figure 2 depicts the total frequency of MIE for teachers 1, 2, and 3 separated by context (i.e., free play, transition, and meal). Despite a downward trend during the intervention phases, teacher 1 was observed using the highest frequency of math instructional episodes during meal time. Although the data for teachers 2 and 3 were highly variable throughout the intervention phases, teachers 2 and 3 initiated the highest frequency of math instructional episodes during transition. Data were relatively stable during baseline in each class. Although variable throughout both intervention phases, there was an upward trend from the high support condition to the low support condition for every class. Overall, the means for free-play, transition, and meal times were 2.02 (SD= .87), 2.67 (SD= 1.88), and 2.99 (SD= 1.16), respectively.
Teacher 1 demonstrated the highest frequency of MIE during meal time ($M=3.81; SD=1.72$). The lowest frequency of MIE, just above the goal of 1.0 MIE/minute, was demonstrated during transition time ($M=1.03; SD=.31$). Teacher 2 also demonstrated the highest frequency of MIE during meal time ($M=2.58; SD=.77$) but exhibited the lowest frequency of MIE during free play ($M=2.08; SD=.50$). Teacher 3 displayed the highest frequency of MIE during transition time ($M=3.96; SD=2.31$) and the lowest frequency of MIE during free play ($M=2.74; SD=.96$). Table 6 shows the total math instructional episode means across contexts.
Table 6

*Total Math Instructional Episodes Means (SD) Across Contexts*

<table>
<thead>
<tr>
<th>Context</th>
<th>Baseline</th>
<th>Intervention Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Play</td>
<td>0.14 (.20)</td>
<td>1.25 (.37)</td>
</tr>
<tr>
<td>Transition</td>
<td>0</td>
<td>1.03 (.31)</td>
</tr>
<tr>
<td>Meal</td>
<td>0</td>
<td>3.81 (.1.72)</td>
</tr>
<tr>
<td><strong>Teacher 2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Play</td>
<td>0.14 (.01)</td>
<td>2.08 (.50)</td>
</tr>
<tr>
<td>Transition</td>
<td>0</td>
<td>2.21 (.96)</td>
</tr>
<tr>
<td>Meal</td>
<td>0</td>
<td>2.58 (.77)</td>
</tr>
<tr>
<td><strong>Teacher 3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Play</td>
<td>0.18 (.04)</td>
<td>2.74 (.96)</td>
</tr>
<tr>
<td>Transition</td>
<td>0.12 (.18)</td>
<td>3.96 (2.31)</td>
</tr>
<tr>
<td>Meal</td>
<td>0</td>
<td>2.78 (1.03)</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Play</td>
<td>0.15 (.09)</td>
<td>2.02 (.87)</td>
</tr>
<tr>
<td>Transition</td>
<td>0.04 (.10)</td>
<td>2.67 (1.88)</td>
</tr>
<tr>
<td>Meal</td>
<td>0</td>
<td>2.99 (1.16)</td>
</tr>
</tbody>
</table>

Teacher’s use of each math-oriented milieu teaching strategy. Figure 3 shows the total distribution of each math-oriented milieu teaching technique (i.e., MITE; MTD; MMM; MM) for all classes during the intervention phases. Each milieu teaching technique is reported as a percent of the total amount of milieu teaching. Fifty-one percent of instructional episodes were
math mand models. Math incidental teaching represented 30% of the total MIE. Math time delay and math model represented 10% and 9% of the total MIE, respectively.

Figure 3. Overall distribution of each math instructional episode during the intervention phase.

Figure 4 shows the total distribution of each math-oriented milieu teaching technique (i.e., MITE; MTD; MMM; MM) for teacher 1 during the intervention phases. Each milieu teaching technique is reported as a percent of the total amount of milieu teaching. Fifty-one percent of instructional episodes were MMM. MITE represented 21% of the total MIE. MTD and MM represented 17% and 12% of the total MIE, respectively.
Figure 4. Distribution of each math instructional episode during the intervention phases for teacher 1.

Figure 5 shows the total distribution of each math-oriented milieu teaching technique (i.e., MITE; MTD; MMM; MM) for teacher 2 during the intervention phases. Each milieu teaching technique is reported as a percent of the total amount of milieu teaching. Forty-nine percent of instructional episodes were MMM. MITE represented 28% of the total MIE. MTD and MM represented 8% and 15% of the total MIE, respectively.

Figure 5. Distribution of each math instructional episode during the intervention phases for teacher 2.

Figure 6 shows the total distribution of each math-oriented milieu teaching technique (i.e., MITE; MTD; MMM; MM) for teacher 3 during the intervention phases. Each milieu
teaching technique is reported as a percent of the total amount of milieu teaching. Fifty-one percent of instructional episodes were MMM. MITE represented 37% of the total MIE. MTD and MM each represented 6% of the total MIE.

Figure 6. Distribution of each math instructional episode during the intervention phases for teacher 3.

**What Intensity of Feedback is Effective in Increasing the Frequency of Math-Oriented Teaching Strategies?**

All three teachers demonstrated frequencies of math instructional episodes that were above their respective goals during every intervention observation. As a result, teachers never progressed into the high-support condition after intervention fluency was initially demonstrated and an analysis comparing the different intensities of support could not be completed. Please see the discussion for further comments.

**How Does an Increase in the Frequency of Math-Oriented Milieu Teaching Strategies Affect Other Classroom Variables?**

Data were collected on two non-instructional classroom variables: positive attention (PA) and teacher managerial behavior (TMB). Positive attention combined instances of attention provided within the context of an instructional episode (e.g., “That is a triangle, great job!”) and instances provided outside of an instructional episode (e.g., “Thank you for sitting in your
Teacher managerial behavior was separated into positive managerial behavior and negative managerial behavior.

**Positive attention.** Figure 7 illustrates the frequencies of PA across contexts. Visual analyses indicated a slightly variable, increasing trend of PA for teachers 2 and 3; teacher 1 was more variable. Means and standard deviations are displayed in Table 7. Overall, the frequency of PA increased from baseline ($M=.35; SD=.11$) to intervention ($M=1.11; SD=.43$).
Figure 7. Frequency of positive attention for teachers 1, 2, and 3 across contexts.

Table 7

Positive Attention Means (SD)

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>High Support</th>
<th>Low support</th>
<th>Intervention Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>.23 (.14)</td>
<td>1.22 (.69)</td>
<td>1.06 (.36)</td>
<td>1.11 (.45)</td>
</tr>
<tr>
<td><strong>Teacher 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>.42 (.23)</td>
<td>.71 (.08)</td>
<td>1.12 (.29)</td>
<td>1.02 (.32)</td>
</tr>
<tr>
<td><strong>Teacher 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>.39 (.26)</td>
<td>.67 (.19)</td>
<td>1.85 (.84)</td>
<td>1.56 (.90)</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>.35 (.11)</td>
<td>.87 (.31)</td>
<td>1.34 (.44)</td>
<td>1.11 (.43)</td>
</tr>
</tbody>
</table>

**Teacher managerial behavior.** Figure 8 shows all instances of TMB disaggregated into positive managerial behavior and negative managerial behavior. The percentage of negative
managerial behavior increased from baseline to intervention for every teacher. Overall, the use of negative managerial behavior increased 11% from 38% to 49%. Teachers used positive managerial behavior 51% of the time during the intervention phases.

**Teacher Managerial Behavior**

![Bar chart showing distribution of positive and negative managerial behavior for teachers 1, 2, and 3 across contexts.]

*Figure 8.* Distribution of positive managerial behavior and negative managerial behavior for teachers 1, 2, and 3 across contexts.

**Will Teachers Trained in the Use of Math-Oriented Milieu Teaching Strategies Evidence Generalization?**

In order to assess generalization, data were collected on two variables: math incidental teaching episodes (MITE) occurring during free-play time (missing toy) and transition time (shape sticks intervention) and non-math instructional episodes (NMIE). MITE and non-math instructional episodes occurring during meal time were not included when assessing generalization because the intervention (something’s fishy) had an incidental teaching episode imbedded in the intervention script; the target contexts/interventions did not. Further analyses were used to determine what percentage of the total frequency of math instructional episodes were unscripted (i.e., teacher initiated; not imbedded within an intervention script) MITE.

**Unscripted math incidental teaching episodes.** Figure 9 shows the frequency of
unscripted MITE during free-play time and transition time. As compared to a baseline frequency of zero, the overall frequency of unscripted MITE during free-play and transition was \( .56 (SD=.72) \) per minute. Teacher 1 demonstrated zero instances of unscripted MITE. Data suggest teacher 2, despite a downward trend at study’s end, demonstrated a higher level of unscripted MITE use from baseline to intervention. Teacher 3 also demonstrated a higher level of unscripted MITE use from baseline to intervention; however, intervention data were more variable as teacher 3 progressed through intervention. Means and standard deviations are displayed in Table 8.
Figure 9. Frequency of unscripted math incidental teaching episodes for teachers 1, 2, and 3 during transition time and meal time.
Table 8

*Unscripted Math Incidental Teaching Means (SD) During Free Play and Transition*

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>High Support</th>
<th>Low support</th>
<th>Intervention Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Teacher 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>.34 (.05)</td>
<td>.52 (.11)</td>
<td>.47 (.13)</td>
</tr>
<tr>
<td><strong>Teacher 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>.53 (.12)</td>
<td>1.43 (.97)</td>
<td>1.20 (.93)</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>.30 (.25)</td>
<td>.65 (.81)</td>
<td>.56 (.72)</td>
</tr>
</tbody>
</table>

Figure 10 illustrates the percentage of total math instructional episodes that were unscripted math-oriented incidental teaching episodes (MITE) during free-play and transition across all three contexts. For all three teachers, across all three contexts, 14% of the total frequency of MIE were unscripted MITE. Teacher 1 evidence zero generalization. However, of the total frequencies of MIE demonstrated by teachers 2 and 3, 12.4% and 21.1% of these episodes, respectfully, were un scripted.
Figure 10. Percentage of math instructional episodes that were unscripted math-oriented incidental teaching episodes for teachers 1, 2, and 3 across contexts

**Non-math instructional episodes.** Figure 11 shows the frequency of non-math instructional episodes (NMIE) during free-play time and transition time. As compared to the overall NMIE baseline frequency of .17 (SD= .15) per minute, teachers initiated NMIE .22 (SD= .50) per minute during intervention. Teacher 1 did not initiate any NMIE during the intervention phase. Teacher 2 initiated NMIE during one intervention observation session; whereas, three of the four baseline observations contained NMIE. Teacher 3 initiated zero NMIE during the first four observations sessions. The remaining observations sessions evidenced an increasing trend and level, though the former was variable. NMIE initiated during these final four observations ranged from .99– 1.66 per minute. Means and standard deviations are displayed in Table 9.
Figure 11. Frequency of non-math instructional episodes for teachers 1, 2, and 3 during transition time and meal time.

Table 9

Non-Math Instructional Episodes Means (SD) During Free Play and Transition Times

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>High Support</th>
<th>Low support</th>
<th>Intervention Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.08 (.11)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Teacher 2</strong></td>
<td></td>
<td>.25 (.17)</td>
<td>.13 (.18)</td>
<td>.13 (.18)</td>
</tr>
<tr>
<td><strong>Teacher 3</strong></td>
<td></td>
<td>.16 (.17)</td>
<td>0</td>
<td>.85 (.72)</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td></td>
<td>.17 (.15)</td>
<td>.04 (.10)</td>
<td>.28 (.57)</td>
</tr>
</tbody>
</table>

62
Social Validity

Table 10 shows the social validity data. Data suggest the procedure was generally well liked and perceived as effective. All questions received an overall mean rating of 4 or higher.

Table 10

Social Validity Results

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean</th>
<th>Mode</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>The milieu teaching procedures were easy to follow</td>
<td>5</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>I liked the procedures used in this intervention</td>
<td>5</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>The intervention was easy to include in my daily routine</td>
<td>5</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>I will continue to use these procedures during free-play time, lunch/snack time, and transition time</td>
<td>4</td>
<td>3; 5</td>
<td>3-5</td>
</tr>
<tr>
<td>Overall, this intervention was beneficial to my students</td>
<td>5</td>
<td>5</td>
<td>-</td>
</tr>
</tbody>
</table>

Note. Two of four participating teachers completed this survey.

Discussion

Overall, the results of this study suggest that graphical performance feedback is an effective method of increasing naturalistic math instruction in the preschool classroom. Though, the use of scripted interventions and an information session concomitant with graphical feedback prohibit concluding that graphical feedback alone is effective in changing behavior. The
frequency of math instructional episodes increased in all three classrooms. Similarly, teachers’ use of positive attention increased from baseline to intervention phases. The teachers implementing the intervention evidenced a decrease in teacher managerial behavior from baseline to intervention. Two of three teachers evidenced generalization.

The four research questions examined in this study were: (a) is graphical feedback effective in increasing the frequency of math-oriented milieu teaching strategies, (b) what intensity of feedback is effective in increasing the frequency of math-oriented milieu teaching strategies, (c) how does an increase in the frequency of math-oriented milieu teaching strategies affect other classroom variables, and (d) will teachers trained in the use of math-oriented milieu teaching strategies evidence generalization?

The first research question addressed the overall effectiveness of the graphical feedback procedure. Results indicated that the combination of intervention and graphical performance feedback was effective in increasing the frequency of math-oriented milieu teaching strategies. These results support the findings of Casey and McWilliam (2008). However, a precise comparison cannot be made between the two data sets for two reasons: (a) Casey and McWilliam (2008) measured the occurrence of incidental teaching episodes as a percentage of intervals and (b) the present study used a training-and-scripted-interventions procedure whereas Casey and McWilliam (2008) used a training-and-room-rearrangement procedure. In addition, this study varied two support conditions.

In regard to the second research question, the present study’s data did not provide sufficient clarity on the most effective intensity of performance feedback. In accordance with the recommendations of Scheeler et al. (2004), teachers were initially taught the milieu teaching strategies by receiving immediate feedback on their performance from the Principle Investigator.
After three consecutive sessions in which the frequency of math instructional episodes exceeded 0.8 per minute, teachers moved into the low-support phase of this study. During all low-support intervention observation sessions, every teacher exceeded the target frequency of math instructional episodes per minute, thereby, precluding any of the teachers from receiving a higher intensity of support. Before suggesting that the present study’s results (i.e., both high-support and low-support phases resulted in 100% goal attainment) support Solomon et al.’s (2012) assertion that there is no significant difference between immediate and delayed feedback, an analysis of the performance goals (see limitations) should be conducted. This analysis might lead one to consider setting higher performance goals and/or allowing goals to be modified during the intervention phases so that a comparison of support packages can be made.

The third research question investigated the effects that an increase in the frequency of math-oriented milieu teaching strategies would have on positive attention (PA), teacher managerial behavior (TMB), and academically-oriented group opportunities to respond (GOR). During the intervention phases, the frequency of positive attention increased as the use of math-oriented milieu teaching strategies increased. This increase incorporated instances of positive attention that were observed within the context of a teaching episode and separate from a teaching episode. Although the observed instances per minute of managerial behavior decreased from baseline, $M=.43 \ (SD=.09)$, to intervention, $M=.15 \ (SD=.09)$, teachers showed an increase in the use of negative managerial behavior by 11%. A near-zero frequency of GOR was observed during baseline and intervention: The increase in milieu teaching had no effect on GOR occurrence.

The fourth research question sought to assess if there was any evidence of generalization.
Imbedding a math-oriented milieu teaching episode in only one of three interventions allowed measurement of teachers’ generalization efforts; a question left unanswered by Casey and McWilliam (2008). Two of the three teachers demonstrated some degree of generalization. As shown in figure 9, teacher 2 applied MITE to the two interventions that did not specifically prompt for such a teaching episode. As compared to teacher 2, teacher 3 applied a significantly higher frequency of unscripted MITE. Generalization was also measured by recording when a teacher applied one of the four math-oriented teaching strategies (i.e., MITE; MTD; MMM; MM) to a non-math concept. During baseline, all teachers were observed implementing milieu teaching strategies to teach non-math concepts (e.g., colors; letters). Aside from one observation, teachers 1 and 2 did not initiate any non-math instructional episodes (NMIE) during the intervention phases. However, teacher 3 was observed initiating .64 (.73) NMIE per minute during the intervention phase.

**Limitations**

Although the results of this current study suggest that providing graphical performance feedback is an effective way of increasing the frequency of naturalistic teaching procedures and positively affecting other classroom variables, these data are not without limitation. First, as evidenced by teachers 1, 2, and 3 reaching the targeted MIE/minute goals of, 1.0, 1.5, and 2.0, respectively, during every observation session, further research is necessary on goal setting. Based on Casey and McWilliam’s (2008) overall mean of 19.1 incidental teaching episodes per thirty-minute observation (.64 incidental teaching episodes per minute; multiple instances of incidental teaching behavior during the same interval were not recorded), the above goals and initial goal, during the high-support phase, of 0.8 MIE/minute were set. However, the present study differed from Casey and McWilliam (2008) in several ways: (a) three additional milieu
teaching strategies (mand model; model; time delay) were measured in the present study; (b) performance feedback was provided on math-oriented milieu teaching frequency; (c) scripted intervention were used; (d) teachers were recorded and provided feedback on a frequency-per-minute scale, as opposed to an interval-based scale. These differences elucidate the need for further research on more appropriate goal-setting procedures.

A second limitation is the use of the *three-point decision rule* to evaluate teacher performance. Adroin, Christ, Morena, Cormier, and Klingbeil (2013), in a review of 102 studies, suggest that, “outcomes should be examined and characterized within the context and purpose that data are used” (p. 14). Although these authors examined decision rules in terms of the curriculum based measurement of reading, a context and purpose different from the present study, their recommendation suggests that the *three-point decision rule* is not a universally valid criterion for making decisions.

Third, teachers 2 and 3 were from the same classroom; coincidentally, these teachers demonstrated the highest frequencies of math instructional episodes. Even though each teacher was treated as a separate participant (i.e., data were kept private; feedback sessions were not conducted while both teachers were present), the teachers might have benefited from observational learning.

Fourth, as noted by Casey and McWilliam (2008), it is difficult to distinguish if the graphical feedback procedure in fact changed teacher behavior or maintained the outcomes produced in the information session. The interventions and the provision of graphical performance feedback were inextricably linked: Following the professional development session, the experimental design of this study called for the immediate implementation of all three interventions accompanied by immediate graphical performance feedback.
Conclusions, Future Directions, and Implications for Practice

Based on the results of this current study, there are several future directions and implications for practice. One such direction is to examine goal setting and, in turn, decision rules and effective levels (e.g., high; low) levels of support. The present study used a goal of 0.8 math instructional episodes per minute during the high-support condition for every teacher and one teacher-specific goal (1.0 MIE/minute for teacher 1; 1.5 MIE/minute for teacher 2; 2.0 MIE/minute for teacher 3) for the low-support condition. In comparing all three teachers, the total frequency of math instructional episodes coincided with the teacher’s goal: the teacher with the highest goal (teacher 3) demonstrated the highest frequency of math instructional episodes and the teacher with the lowest goal (teacher 1) demonstrated the lowest frequency of math instructional episodes. Future researchers might consider increasing goals based on teacher performance, as opposed to having an unchanging goal. Using a more fluid approach to goal setting will also allow researchers to begin to explore math-oriented teacher behavior as a context; thus, further evaluating the appropriateness of context-specific decision rules.

In turn, the application of an individualized goal-setting procedure in combination with context-specific decision rules will allow researchers to continue the investigation of effective levels of graphical feedback support.

A second direction, and natural extension of this study, is to investigate the relationship between an increase in naturalistic math instructional opportunities and student outcomes. The present study asked teachers to work with students of all different mathematical abilities. Targeting students that are more in need of supplemental math instruction and monitoring student growth would provide important information on the viability of increasing math-oriented teacher behavior as a tier 1, 2, or 3 intervention.
A third direction of future research is to focus on the generalization of math-oriented instruction behaviors. The present study made use of three scripted interventions that were designed to be used during a specific time of the day. Only one of the three interventions contained an impeded math-oriented incidental teaching episode. The results of this study showed that two of the three teachers incorporated unscripted math-oriented incidental teaching episodes when using the other two interventions. Future researchers might consider two separate methodological variations of the present study to further assess the generalization of math-oriented instructional behaviors. Similar to Casey and McWilliam (2008), researches could choose to forego the use of scripted interventions. Alternatively, researchers might extend the current study removing all intervention materials once stable responding has been established during the intervention phase. This removal might provide additional information on teachers’ ability to generalize the information learned.

One implication for practice of this study, as noted by Scheeler et al. (2004), is that teachers are able to learn new teaching skills in a relatively short time with minimal post-skill-acquisition support. Using graphical feedback with teachers provides: (a) a tangible representation of performance; (b) rewards (e.g., seeing data above the goal line) for meeting goals; (c) a medium for progress monitoring of behavior. In combination with a strong training paradigm, system-wide use of graphical feedback would provide a method for increasing desired teacher behaviors, a means of teacher support, and a way to promote accountability. An additional implication, based on this study’s social validity data, is that teachers were highly accepting of the graphical feedback and naturalistic math teaching procedures and would be open to their use in the future. This supports previous findings that naturalistic teaching procedures
and performance feedback are highly acceptable to teachers (Barnett, Carey, & Hall, 1993; Casey & McWilliam, 2008; Duchaine, Jolivette, & Fredrickes, 2011).

In conclusion, the procedures used in this study have clear utility as a method for increasing the math-oriented, naturalistic instructional behaviors of teachers. In the preschool classroom that continues to place an increased emphasis on empirically-based instruction (see Barnett et al., 2007), graphical performance feedback merits continued investigation into its effectiveness.
References


Appendix A

Teacher Recruitment Flyer

University of Cincinnati

Department: School Psychology

Principal Investigator: Richard Marsicano

Faculty Advisor: Dr. Dave Barnett

Dear Classroom Teachers,

As a part of my doctoral studies in School Psychology, I am planning to conduct a research study on naturalistic teaching procedures. This research will involve attending a professional development session, providing extra instruction, and being observed 1-3 times per week for no more than 40 minutes at a time. The observations will be done for up to nine weeks and will be done when it is convenient for you.

If interested, you will participate in a professional development session that will provide information on milieu teaching strategies, information on early language development, and intervention selection and design information. You will then be asked to use these interventions incorporating milieu teaching in your classroom during free-play time, lunch/snack time, and transition time while a trained graduate students record the amount teaching that is used. Prior to each observation session, you will be shown a graph that shows how much milieu teaching was observed during the previous observation. You will then be asked to try and beat your previous score. This study will not be used to critique your teaching style and will not be used as a means to evaluate your performance as a teacher. Information collected is only intended determine if feedback can result in more milieu teaching.

If you would like your classroom to be included, or you would like more information, please contact me (marsicrt@mail.uc.edu) or let a second-year student know of you interest and I will contact you. Thank you.

Sincerely,

Richard Marsicano, M.Ed., MA
University of Cincinnati
Appendix B

Teacher Consent Form

Adult Consent Form for Research
University of Cincinnati
Department: School Psychology
Principal Investigator: Richard Marsicano
Faculty Advisor: David Barnett, Ph.D.

Title of Study: Increasing Milieu Teaching During Non-Instructional Time via a Graphical Feedback Support Continuum

Introduction:
You are being asked to take part in a research study. Please read this paper carefully and ask questions about anything that you do not understand.

Who is doing this research study?
The person in charge of this research study is Richard Marsicano of the University of Cincinnati (UC) Department of School Psychology. He is being guided in this research by David Barnett, Ph.D. There may be other people on the research team helping at different times during the study.

What is the purpose of this research study?
The purpose of this research study is to see if graphical performance feedback can increase the amount of milieu teaching in the preschool classroom.

Who will be in this research study?
Approximately 3-6 teachers will be in the study. You may be in this study if:
- You feel additional instructional episodes will benefit your students
- You are a teacher in one of the selected Head Start centers

What if you are an employee where the research study is done?
Taking part in this research study is not part of your job. Refusing to be in the study will not affect your job. You will not be offered any special work-related benefits if you take part in this study. Data from this research study will not be shared with your employer.

What will you be asked to do in this research study, and how long will it take?
- You will be asked to provide increased instruction during free-play time, snack/lunch time, and transition time. Each observation session will last no longer than 40 minutes. The research will take place in your classroom as you interact with your children. These interactions will be observed and notes will be taken about your (the teacher’s) activities and not the children’s. The observations will be done for up to nine weeks and will be done when it is convenient for you.
- You will be asked to attend a professional development session milieu teaching that will last approximately 45-120 minutes. This training will be done when it is convenient for you.
you and can be broken into two sessions if you would prefer.

- You will be asked to fill out a social validity survey to determine if the procedures were acceptable, favorable, and to see if you thought there were any meaningful changes in behavior as a result of the student procedures. This survey will take approximately 2-5 minutes.

**Are there any risks to being in this research study?**
It is not expected that you will be exposed to any risk by being in this research study.

**Are there any benefits from being in this research study?**
Because of being in this research you might learn how to provide more instruction during free-play time, lunch/snack time, and transition time.

**What will you get because of being in this research study?**
You will not be paid (or given anything) to take part in this study.

**Do you have choices about taking part in this research study?**
If you do not want to take part in this research study you may simply not participate.

**How will your research information be kept confidential?**
Information about you will be kept private by:
- using a study ID number instead of the participant's name on the research forms
- limiting access to research data to the research team
- not including the participant's name on the typed transcript
- keeping research data on a password-protected computer

Your information will be in a locked cabinet in the faculty researcher's campus office for 3 years. After that it will be destroyed by shredding paper forms and deleting computerized forms.

Agents of the University of Cincinnati may inspect study records for audit or quality assurance purposes.

**What are your legal rights in this research study?**
Nothing in this consent form waives any legal rights you may have. This consent form also does not release the investigator, institution, or its agents from liability for negligence.

**What if you have questions about this research study?**
If you or your child has any questions or concerns about this research study, you should contact Richard Marsicano at 732-754-6824 or marsicrt@mail.uc.edu
Or, you may contact David Barnett, Ph.D. at 513-556-3338 or barnetdw@ucmail.uc.edu

The UC Institutional Review Board reviews all research projects that involve human participants to be sure the rights and welfare of participants is protected.

If you have questions about your rights as a participant or complaints about the study, you may contact the UC IRB at (513) 558-5259. Or, you may call the UC Research Compliance Hotline at (800) 889-1547, or write to the IRB, 300 University Hall, ML 0567, 51 Goodman Drive,
Do you HAVE to take part in this research study?
No one has to be in this research study. Refusing to take part will NOT cause any penalty or loss of benefits that you would otherwise have.

You may start and then change your mind and stop at any time. To stop being in the study, you should tell Richard Marsicano at 732-754-6824 or marsicrt@mail.uc.edu. If you stop being in the study, all information collected about you will be removed from the research study.

Agreement:
I have read this information and have received answers to any questions I asked. I give my consent to participate in this research study. I will receive a copy of this signed and dated consent form to keep.

Participant Name (please print) ____________________________________________

Participant Signature ________________________________________________ Date ______

Signature of Person Obtaining Consent _______________________________ Date ______
Appendix C

Teacher Recruitment Script

• Introductions: Fourth year doctoral student from the University of Cincinnati

• Discuss the teacher’s classroom concerns (if any)
  o Will students benefit from additional instruction?

• Introduce research study
  o Third year research project on milieu teaching strategies under the supervision of Dr. Dave Barnett
  o Discuss the four types of milieu teaching strategies
  o The observations will be done for up to nine weeks and will be done when it is convenient for you
  o Teachers will receive professional development on milieu teaching and intervention development

• PI/graduate students will briefly consult with teachers concerning the teacher’s use of milieu teaching
  o Teachers will be observed 1-3 times per week during free-play, lunch/snack, and transition times for no more than 40 minutes at a time
  o Teachers will then be asked to engage in milieu teaching with students of their choosing
  o No student data will be recorded
  o Goals of study: Improve the number of instructional episodes that occur during free-play time, lunch/snack, and transition

• If interested, describe their role (teachers):
  o Go over the steps of the study
  o Attend milieu teaching professional development
  o Observed 1-3 times a week by PI or trained graduate students
  o Fill out social validity survey at the end of the intervention

• Consent procedures and/or give them more time to consider their participation. Teachers will be given the PI’s contact information.
  o PI contact information will be on the consent forms
Appendix D

Observation Code

Classroom: __________ Room Number: __________ Date: __________

Observer: __________

Inter-Rater Check: Y  N

Primary Observation: Y  N

Initial Start Time: __________

Final End Time: __________

Activity 1: __________ Start Time: __________ End Time: __________

Activity 2: __________ Start Time: __________ End Time: __________

Activity 3: __________ Start Time: __________ End Time: __________

Activity 1 Total Time: __________

Activity 2 Total Time: __________

Activity 3 Total Time: __________

Total Observation Time: __________
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Activity: ____________________             _________________             __________________
## Post-observation Calculations

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</table>

### Intervention Adherence:

*Percentage of steps completed: _______________

List steps not consistently observed: _______________

*Total Math Milieu Teaching Strategy Frequency:

* = to be used as graphical feedback variable
Appendix E
Observation Code Quiz

NAME: __________________________

1. Dependent variables (excluding adherence) are recorded using ____________.
   A. partial interval recording
   B. frequency count recording
   C. frequency/minute recording
   D. A&B

2. All observation intervals must cover all three times of the day that are of interest (i.e., snack/meal; free-play; transition).
   True
   False

3. You observe for a total of 12 minutes and 40 seconds. How would you record this total time on your sheet?
   A. 12.4 minutes
   B. 12.2 minutes
   C. about 13 minutes
   D. 12.66 minutes

4. You record 20 episodes of incidental teaching in 10 minutes and 30 seconds. How many episodes of incidental teaching did you observe per minute?
   A. 1/min
   B. 1.90/min
   C. 2.10/min
   D. 2.66/min

5. A bout of positive attention contained within an episode of incidental teaching should be counted as both an episode of incidental teaching and an episode of positive attention.
   True
   False

6. Teacher managerial behavior should be disaggregated into positive and negative instances
   True
   False
7. Math instructional episodes will be calculated after each observation by taking the total frequency of MITE, MM, MMM, and MT that are recorded during your observation.

   True

   False

8. Please look at the fish intervention for context for this question.

   During an intervention-implementation observation the teacher demonstrates all of the steps of the math incidental teaching variable up to the student answering. When it comes time for the student to respond she (the child) does not say anything. The teacher then pauses for five seconds (time delay) waiting for a response. The teacher then asks the student how many fish she has in her hand (mand). The teacher then tells the student she asked for four fish and only has three so she needs to ask for one more (model). After the most recent prompt the student responds correctly by asking for another fish. The teacher praises her and gives her the extra goldfish snack. How should you code this interaction?

   A. Math Incidental Teaching, Math Mand, and Math Mand-Model

   B. Math Incidental Teaching

   C. Math Mand-Model


9. What’s the difference between “Student Fail” and “Teacher Fail” incidental teaching episodes?

   A. How you record what follows

   B. Who made the “error” in the incidental teaching episode

   C. Nothing

   D. A&B
10. (This entire question spans 10 minutes in total). During a transition-time observation the main teacher is following the appropriate script by going around to each student an obtaining the correct number of squares on an index card. The main teacher takes exactly 5 minutes to obtain an answer from all but one student. All of the students that have successfully answered the prompt are playing on the carpet (being supervised by the assistant teacher). The main teacher then takes 2 additional minutes to try and obtain a correct answer from the student at the table. For whatever reason, the teacher then leaves the student at the table by herself and joins the rest of the class. Three minutes later the student at the table joins the rest of the class on the carpet. How long was your observation of transition time?

A. 5 minutes  
B. 7 minutes  
C. 8 minutes  
D. 10 minutes
## Appendix F

### Examples of Math Milieu Teaching Activities

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Intervention</th>
<th>New Materials Needed</th>
<th>What might it look like?</th>
<th>Early Math Skills Targeted</th>
<th>Milieu Teaching Technique</th>
</tr>
</thead>
</table>
| Free play   | Missing Toy  | index cards depicting math concepts; non-used toy | 1. Establishes joint attention  
2. Takes one play material from child  
3. Place taken toy and unused toy in front of two index cards depicting two similar math concepts (e.g., more/less)  
4. Ask child which toy he or she wants  
5. Wait 3-5 seconds for response  
6. Provide access to toy and praise when correct  
7. Provide a corrective model, praise, and access when incorrect | One-to-one correspondence; subitizing; counting; shapes | - Time delay  
- Mand model |
| Transition  | Shape Sticks | Sets of colored toothpicks | 1. Before moving on to next activity, approach child and allow them to pick a color of toothpick they like  
2. Take 3 toothpicks, for example, and make a triangle  
3. Ask child to identify the shape  
4. Wait 3-5 seconds  
5. Praise if correct or provide model and praise if incorrect  
6. Ask child how many toothpicks were used  
7. Wait 3-5 seconds | Shapes; counting; | - Time delay  
- Mand model |
| Meal Time/ Snack Time | Something’s Fishy | Goldfish snacks | 1. Ask the child a question about fish (e.g., what is your favorite fish) to establish joint attention  
2. Ask child how many goldfish he or she wants  
3. Give child less than requested amount  
4. Wait 3-5 seconds  
5. If child requests correct amount provide the fish along with praise  
6. If child does not request correct amount provide the fish along with a model and praise | One-to-one correspondence; subitizing; counting | Incidental teaching  
Time delay  
Modeling |
|-----------------------|------------------|-----------------|---------------------------------------------------|------------------|-----------------|
|                       |                   |                 | 8. Praise if correct or provide model and praise if incorrect  
9. Allow child to transition to next activity |                   |                 |
Appendix G

Example Graph Used in the Graphical Feedback Session

**Total Math Instructional Episodes**

Baseline | High support | Low support
---|---|---

Goal (1.5)
Appendix H

Teacher Social Validity Survey

Purpose: The purpose of this questionnaire is to get feedback concerning your overall satisfaction with the intervention(s) implemented in your classroom.

Directions: Please read the following statements and circle the number (1-5) that best describes your agreement or disagreement with each statement.

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<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Disagree</th>
<th>Not Sure</th>
<th>Agree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The milieu teaching procedures were easy to follow</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I liked the procedures used in this intervention</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The intervention was easy to include in my daily routine</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>I will continue to use these procedures during free-play time, lunch/snack time, and transition time</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Overall, this intervention was beneficial my student(s)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Please make any additional comments below.

___________________________________________________________________________________________

___________________________________________________________________________________________

___________________________________________________________________________________________

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Appendix I

Something’s Fishy Script

Materials needed: Goldfish snacks

1. Wait for students to exit the lunch line OR approach a student while he/she is eating
2. Ask the student a question about fish (e.g., “What’s your favorite fish?”, Which is cooler, a goldfish or a shark?)
3. Ask the student how many fish he/she want
4. Give the student less or more than the requested amount
5. If students tells you that is not the amount he/she asked for, provide verbal praise (e.g., “Great!”) and give them one extra fish
6. If student doesn’t immediately acknowledge wrong amount you may:
   - Wait 2-3 additional seconds to see if the student realizes the amount is wrong - if correct answer is not given then,
   - Ask student if he/she received the amount of fish requested (e.g., Did I give you the 3 fish you asked for?) – if correct answer is not given then,
   - Tell the student you gave them the wrong amount and explain to them why it’s wrong (e.g., I gave you one too many/little).
7. Provide verbal praise (e.g., “Great!”) and give the student one extra fish
8. Wait for or approach next student and repeat steps 1-7
Appendix J
Graphical Feedback Adherence Script

Two minutes prior to each observation requiring feedback, please ask the teacher to meet with you and say the following:

1. “During the last observation you initiated _____/min math instructional episodes and completed _____ % of intervention steps (point to the corresponding numbers on the graph).”

2. “The goal that you set for yourself was _____/min and 100% of intervention steps.”

3. If the teacher met or exceeded the expected goals please say, “Great job meeting your goals. See if you can repeat your performance.”

4. If the teacher did not meet or the expected goals please say, “Although providing _____/min instructional math episodes and/or demonstrating _____ % of intervention steps is great, you fell short of your goal. Let’s try and hit your goal of _______/min and/or 100% of intervention steps during this observation.”
   
   a. If the teacher did not meet the math instructional episodes please say, “based on the data if you increase your use of _______ milieu teaching strategy during _______ time you should be able to meet your goal.*”

   b. If the teacher did not meet the intervention adherence goal please say, “here are the steps I didn’t see during the last round of observation ______________ (list each step missed).”
Appendix K

Missing Toy Script

Materials needed: Toy burglar costume; math index cards; unoccupied toy(s)

1. Walk over to a student while he/she is playing
2. “Steal” one of the toys the student is playing with
3. Take two index cards and place them face up in front of the student
4. Place the stolen toy on top of or next to one of the index cards
5. Place the unoccupied toy on top of or next to the other index card
6. Tell the student that to reclaim their stolen toy they must ask for it by the concept described on the index cards
   - For example: Using the more/less index cards, you can ask, “To get your toy back you must answer this question: Is your toy on top of the index card with more dots or on top of the index card with less dots?”
7. If the student is correct, give the student back their toy and provide verbal praise (e.g., “Good job”)
8. If the student is incorrect, provide a corrective model (e.g., “Your toy was on the index card with more dots so say ‘Can I have the toy that is on the card with more dots?’”)
9. Give the student back their toy and provide verbal praise (e.g., “Good job”)
10. Approach next student and repeat steps 1-9
Appendix L

Shape Sticks Script

Materials needed: Shape sticks

1. Prior to transitioning, approach the student and ask them a question about shapes (e.g., “What’s your favorite shape?”
2. Transition the conversation to the shape sticks (e.g., “How about I make a shape…”)
3. Take a few shape sticks and make a shape (e.g., take 3 sticks and make a triangle)
4. Wait 2-3 seconds to see if student correctly identifies the shape
5. If the student answers correctly, provide verbal praise (e.g., “Great job!”)
6. If the student doesn’t answer, ask the student to identify the shape
7. If the student answers correctly, provide verbal praise (e.g., “Great job!”)
8. If there is no answer or an incorrect answer tell the student the name of the shape and ask them to repeat it/acknowledge it (e.g., “That’s a triangle, right?”)
9. Provide verbal praise (e.g., “Great job!”)
10. Allow the student to proceed with the transition
11. Approach next student and repeat steps 1-10
Appendix M

Something’s Fishy Adherence Checklist

Teacher approaches the student and initiates a conversation about fish

Teacher asks the student how many fish he/she wants

Teacher gives the student the wrong amount

Teacher waits 2-3 seconds for the student to realize they were given the wrong amount

AND/OR
Teacher asks the student if they were given the amount of fish that was asked for
AND/OR
Teacher tell the student they were given too many/little

Teacher provides verbal praise

Percent Adherence: ____________________________________________
Appendix N

Missing Toy Adherence Checklist

Teacher approaches student that is playing

Teacher takes the stolen toy and unused toy and places them on the index cards

Teacher asks student to identify the concept corresponding with the stolen toy (mand/model)

OR

Teacher tells student the concept corresponding with the stolen toy (model)

Teacher gives the student the stolen toy

Teacher provides verbal praise

Percent Adherence:________________________________________
Appendix O

Shape Sticks Adherence Checklist

Teacher approaches the student and initiates a conversation about shapes

Teacher transitions conversation to the shape sticks

Teacher makes a shape with the shape sticks

Teacher waits 2-3 seconds for the student to name the shape
AND/OR
Teacher asks the student to name the shape
AND/OR
Teacher tells the student the name of the shape

Teacher provides verbal praise

Teacher allows the student to transition

Percent Adherence:________________________________________