Teaching and Teacher Education 71 (2018) 78–85

Contents lists available at ScienceDirect

Teaching and Teacher Education

journal homepage: www.elsevier.com/locate/tate

An embodied cognition approach to enhancing reading achievement in New York City public schools: Promising evidence

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HIGHLIGHTS

- This study examined the impact of a dance program involving embodied cognition.
- The sample included fourth grade students in New York City Public Schools.
- The analysis of student achievement scores and teacher survey results are reported.
- Results reveal an increase in reading scores between pretest and posttest.
- Teachers reported adequate fidelity of implementation.

ARTICLE INFO

Article history:
Received 23 February 2017
Received in revised form
2 November 2017
Accepted 8 November 2017

Keywords:
Academic achievement
Dance
Embodied cognition
Schools
Teachers

ABSTRACT

The study purpose was to examine the relationship between the Mark DeGarmo Dance (AKA Dynamic Forms, Inc.) (MDD) program, involving principles of embodied cognition, and student achievement over time. The sample included fourth grade students ($N = 169$) in schools ($N = 4$) in New York City Public School District whose teachers and students participated in the MDD program. Using a pretest posttest single group design and hierarchical linear modeling, the results of this study analyze student achievement as measured by standardized test scores. Teacher survey results are also reported. The achievement results reveal a significant increase in reading between pretest and posttest for students that were in the program. Teachers reported adequate fidelity of implementation.

1. Introduction

Too many children in Title I schools are failing to develop an adequate basis in reading in their early schooling, and this may hold them back in key learning concepts for their entire lives. With educational reform that stresses accountability dominating the current policy climate, improved student academic achievement is critically relevant. Over the last decade, researchers and policy-makers have increasingly focused on the effectiveness of arts and culture programs in raising student achievement and transforming schools. Yet, research shows that only 7% of U.S. elementary schools teach dance as part of regular curriculum. In addition, less than 4% of schools receive outside funding for a dance program (Bonbright, Bradley, & Dooling, 2013). Despite this, there exists some literature that supports links between dance programs and student achievement, highlighting the need for arts and culture in schools, and the implementation of dance in particular (Bonbright et al., 2013; Catterall, Dumais, & Hampden-Thompson, 2012). Researchers and theorists that support this link point to the mechanism of embodied cognition which may facilitate enhanced learning through dance.

The relationship between emotion, cognition, and the body matter in teaching, learning and learning to teach (Corcoran & Tormey, 2010; 2012a; 2012b). Neuroscientific research and theory on embodied cognition is well established (Alibali & DiRusso, 1999; Anderson, 2003; Ansari, 2008; Broaders, Cook, Mitchell, & Goldin-Meadow, 2007; Fayol, Barrouillet, & Marinthe, 1998; Goldin-Meadow et al., 2009; Johnson, 1987; Link, Moeller, Huber, Fischer, & Nuerck, 2013; Varela, Thompson, & Rosch, 1991; Wilson, 2002). While many embodied cognition theories exist (Wilson, 2002), the

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https://doi.org/10.1016/j.tate.2017.11.010
0742-051X/

basic interpretation refers to how "human cognition is originally rooted in sensori-motor processes and thus determined by bodily experiences" (Fischer, Moeller, Bientzle, Cress, & Nuerk, 2011, p. 178). Recent research in cognitive neuroscience has suggested strategies that may help young children build foundational concepts and skills. Recent evidence from cognitive neuroscience suggests that academic skills are linked to parietal and frontal brain areas responsible for body movement in space, and lab experiments suggest that teaching children emphasizing movement and space may help them learn. Yet these principles have not been rigorously tested in applied settings or in preparing teachers and school leaders to meet the demands of the profession (Corcoran, 2017a, 2017b; Corcoran, & O'Flaherty, 2016; 2017a, 2017b).

The current study attempts to examine the effectiveness of the Mark DeGarmo Dance program (AKA Dynamic Forms, Inc.) (MDD). The approach evaluated grows directly out of cognitive neuroscience theory and research on embodied cognition, and represents the first rigorous evaluation of an approach supported by cognitive neuroscience lab research in actual schools over a significant period of time (i.e., a minimum study duration of 12 weeks). The criterion of 12 weeks has been applied in previous systematic reviews (Samdal, Eide, Barth, Williams, & Meland, 2017).

1.1. Problem

Far too many students in high-need schools across America do not read at national norms (National Center for Education Statistics, 2015). Children who are both non-proficient readers and living in high poverty are at even higher risk. According to a 2015 report of the National Assessment of Educational Progress (NAEP), 52% of fourth grade children not qualifying for reduced or free lunch scored above or at "proficient" in reading compared to 21% of fourth grade children qualifying for reduced or free lunch. Further, 46% of whites scored above or at "proficient," compared to 21% of Hispanics and 18% of African-Americans (National Center for Education Statistics, 2016). Students who struggle to read are at much greater risk for referral to special education, grade retention, and school drop-out (Neuman & Dickinson, 2003). Students who can read proficiently are more likely to be career and college ready (Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996). Conversely, students experiencing difficulty reading are at risk for long-term struggles with academic achievement (Neuman & Dickinson, 2003). Clearly, all U. S. schools have a great deal of room for improvement, but schools that serve many high-need students, and disadvantaged students of all races, are in crisis. New solutions including evidence-based programs[1] are needed to improve reading achievement nationwide for all subgroups of children.

1.2. Theory and research on embodied cognition

In the field of affective, cognitive, and neuroscience research, researchers often attempt to explain phenomena using a conceptual framework that encompasses three distinct, but inter-related levels of analysis: psychological processes, experience and behavior, and neural systems (Ochsner, Silvers, & Buhle, 2012). In conjunction with objective measurement, neuroimaging procedures allow phenomena to be observed in a behavioral and neural level and researchers can then utilize these observations to deduce the relationship of mediating affective and/or cognitive processes (Ochsner et al., 2012). Using this as a starting point, this review of the extant literature is organized in terms of the behavioral level phenomena. In other instances this review will be structured in relation to problems that concern the neural-level pathways from which the research has made considerable strides within the field. As a whole, the research being reviewed limits and impacts our understanding of whether a teaching approach based on embodied cognition leads to significant improvements in reading achievement.

Embodied cognition is well established in neuroscientific theory and research (Alibali & DiRusso, 1999; Ansari, 2008; Broaders et al., 2007; Dehaene, 2005; Fayol et al., 1998; Goldin-Meadow et al., 2009; Gracia-Bafalluy & Noël, 2008; Immordino-Yang & Damasio, 2007; Link et al., 2013; Menon, Rivera, White, Glover, & Reiss, 2000; Tschentscher, Hauk, Fischer, & Pulvermüller, 2012; Wilson, 2002). The basic interpretation describes how "human cognition is originally rooted in sensori-motor processes and thus determined by bodily experiences" (Fischer et al., 2011, p. 178). Research (Barsalou, 2008; Wilson, 2002) shows that embodied cognition concepts increase student's satisfaction and confidence about learning (Zhou, 2012), and may improve academic achievement (Fischer et al., 2011). Developments in neuroscience specifically links body movements with academic achievement. For example, in fMRI research Michaux et al. (2013) and Krinzinger et al. (2011) found that finger movements are linked with mental arithmetic.

There exists a growing body of literature to suggest that having children participate in whole-body or finger movements in order to aid in internalizing mathematical concepts complements the learning process when compared to identical actions that lack whole-body or finger movements (e.g., Fayol et al., 1998; Gracia-Bafalluy & Noël, 2008). Link et al. (2013) conducted a study where first graders were taught to designate a researcher-provided number by walking via a number line on the ground to the location of the same number. These children improved substantially from this procedure compared to those children who were assigned the same number line directions, but did not move to the numbers.

Alibali and DiRusso (1999) discovered that having preschoolers gesture while they counted objects improved precise counting and minimized errors. When child participants made hand gestures while explaining solutions to unique problems, this provided a mechanism for solving the immediate problem but also aided in solving future problems, compared to those children who were not instructed to use hand gestures (Broaders et al., 2007). Another study found similar positive effects of encouraging children to utilize gestures for problem solving (Goldin-Meadow et al., 2009).

Fischer et al. (2011) found high-need students that took part in a digital dance mat activity showed improvements on a standardized achievement test. Fisher, Hirsh-Pasek, Newcombe, and Golinkoff (2013) showed that preschool students acquired increased geometric knowledge as a result of "guided play" compared to students taught using traditional, didactic methods.

These research projects empirically support the premise that actively participating in activities may improve students' academic performance. However, much of this prior research involves brief and artificial studies. Rigorous research is needed to test embodied cognition in a more intensive classroom intervention, both to learn how strategies applying this neuroscience principle might increase learning, but also to enrich theoretical work with pragmatic findings worth subjecting to more structured tests.

1.3. Mark DeGarmo Dance (AKA Dynamic Forms, Inc.) (MDD)

Mark DeGarmo Dance (AKA Dynamic Forms, Inc.) (MDD) was founded in 1987 based on a commitment to education and the arts, dance arts creativity and performance, and intercultural community. Its educational vision is to inspire social responsibility through

[1] In this article, the term "program" refers to any combination of professional development, textbooks, computer software, professional development, or interventions that a teacher or school could implement in order improve outcomes, particularly achievement.

the arts and dance. MDD has served at-risk youth living in underserved communities in New York City public schools since 1991. Its dance curriculum is designed to help low-achieving students succeed academically by focusing on teaching problem solving, encouraging creativity, and increasing students' expectations and confidence. It is structured as a 16-week program, with 45- to 60-min weekly sessions, offering dance education that is sequential and linked to learning standards and class curriculum. Some of the features of MDD include:

- Initial brainstorming and mind-mapping session with students and teachers led by teaching artists to find out what all participants know about a selected inquiry topic.
- Teaching artists teach memory-building and analytical skills through review of previous lessons and reflection.
- Reflective practice includes student self-assessment of progress toward agreed-upon goals.
- Students self-assess their progress in dance journals and weekly group discussion.
- Program culminates in a sharing event for peers, parents, and school community.

Further information pertaining to the program is available at http://markdegarmodance.org/.

The MDD theory of change for the impact of embodied cognition on student achievement has several components which are hypothesized to have an additive effect. First, the MDD embodied cognition approach provides students practice that engages their whole bodies creating "motor memories" of carrying out specific actions, which in turn may help the students easily access these memories in order to recall associated concepts having done physical actions (e.g., Fayol et al., 1998; Gracia-Bafalluy & Noël, 2008). Second, the MDD embodied cognition approach builds automaticity in specific functions, that help students to execute these functions rapidly and do so effortlessly with time to concentrate on higher processes (see Tschentscher et al., 2012). Third, MDD aids the students in participating in embodied cognition activities, that are enjoyable and exciting, thus engaging the students to exert more time and energy in reading. In effect, the motivational influence becomes crucial for additional hypothesized paths, as participants must habitually train these embodied cognition activities to internalize them, either as automaticity or resources are made accessible for future learning. Cognitive neuroscience provides an appropriate theoretical foundation for applying embodied cognition concepts within these interventions and justifies studying embodied cognition as a key element of the MDD program to enhance the reading achievement of disadvantaged students.

1.4. Prior research on MDD

Prior investigations into MDD program efficacy have so far revealed only two primary research projects. Cavin, Levy, Pyle, DeGarmo, and Mitchell (2005) conducted a three-year study involving an elementary school in NYC. The authors report significant positive associations between student behavior and dance/theatre journal writing: students wrote longer sentences and more words when they had not disrupted the class.

Second, in 2015, MDD also ran the program in five Title 1 schools in Lower Manhattan involving 1500 Pre-K-5 students and 200 teachers. The project focused on observations, dance journals and program implementation (DeGarmo & Thomasson, 2016). However, all of these prior evaluations on the MDD program are limited due to the uncontrolled nature of the comparisons, along with issues associated with a lack of data and inadequate statistical methods.

The current study examines the relationship between MDD program and student achievement as measured by the New York State Reading Assessment over time (New York State Department of Education, 2015). Data for the fidelity of implementation measure include a teacher survey. The New York City Department of Education is the largest public school system in the U.S., serving about 1.1 million students in almost 1800 schools in 2013–2014 (2013a).

This study builds on the extant literature on MDD programs by assessing academic achievement, specifically reading comprehension scores as an outcome. Theory suggests that the MDD dance curriculum should have an impact on students reading and this study attempts to explore that relationship where prior literature has not attempted to do so. In addition, a stronger research design was pursued to increase confidence in inference for the results of the study, consistent with the U.S. Department of Education recommendations with regard to promising evidence (more on this in methods section). Lastly, the state standardized reading scores have been established as a valid and reliable outcome, improving on the outcomes of prior studies. Given these elements, this study contributes substantively to the literature. The examination of the literature elicited the following research questions that drove this study.

RQ_1: What is the relationship between the MDD program and fourth grade students' reading achievement in treatment schools over time?
RQ_2: Is the MDD program implemented by the teachers completed with high fidelity across treatment schools?

2. Methods

The research design for the current study is a pre-post design without a comparison group. According to the Every Student Succeeds Act (ESSA, 2015), the U.S. Department of Education recommends the use of a well-implemented and well-designed correlational study of an intervention in order to be supported by *promising evidence* (United States Department of Education, 2016). This design meets the criteria for evidence that an intervention may have promise, and therefore constitutes proven programs. Four Title 1 schools were selected to receive the intervention (New York City Department of Education, 2013b). A single cohort was evaluated as 3rd graders in the 2014–2015 school year on reading scale scores and again as 4th graders in the 2015–2016 school year. The intervention was implemented in the 2015–2016 school year. This cohort was chosen because 3rd grade is the first year that the state begins administering standardized testing of student academic outcomes and this cohort provided a good initial exposure of young students to the intervention while maximizing the number of student participants involved. There were more students in the 3rd grade/4th grade cohort than in other cohorts, comparatively. Data was available for schools not in the intervention, but repeated draws of a random sample of four schools failed to meet baseline equivalence standards. This made a comparison group design inappropriate for the current study. A missing data analysis was performed to establish whether the distribution of missing values would bias the inferences of the study. For the key study variables, the total proportion of missing values comprised only 2.0% of the total values in data matrix. In addition, Little's MCAR test was conducted to assess whether the missing data mechanism was random (MCAR) or systematic (Little, 1988). The test revealed that the data was not MCAR, $\chi^2(8) = 32.11$, $p < 0.001$. However, due to the very small proportion of missing values in the data (2%), and the moderate sample size ($N > 100$), it was decided that listwise deletion would be appropriate for analysis (Little & Rubin, 2002). In addition, sensitivity analysis using mean substitution did not

significantly change the results of the analysis. It is presumed that the small number of schools ($N = 4$) added to the variability in the outcome measure at pretest and will be the goal of future research to expand this number of schools and better matching procedures. Since each student had repeated scores in one school, a 2-level multilevel model was chosen to test the effect of treatment from pretest to posttest while accounting for the variance of students. A linear mixed model (LMM) was conducted in SPSS to estimate the effect. The reading score was designated the first level and the student was specified as the second level as a random effect. The year (pretest-posttest) was specified as the fixed-effect predictor in the first level. The multilevel model is discussed in detail later.

An Institutional Review Board (IRB) approved this study for these research purposes. Ultimately, this study was compliant with all guidelines and requirements specified in the *Standard Operating Policies and Procedures Handbook* published by the IRB. This research was supported by funding from MDD. However, any opinions expressed in this manuscript are solely those of the author's.

2.1. Demographics

The final sample size for this project consisted of $N = 169$ elementary school students. The majority of the students in the sample were male ($n = 87$; 51.5%) and the vast majority of these students were minorities ($n = 164$; 97.0%) with black students accounting for the largest group ($n = 82$; 48.5%). The demographic characteristics of the elementary school sample are displayed in Table 1.

2.2. Measures

2.2.1. Reading achievement

The dependent variable (posttest) was students' fourth grade reading achievement measured by the 2016 New York State Reading Assessment (NYSRA) English Language Arts (ELA) scale score. This state assessment measures a student's reading comprehension with regard to understanding key concepts such as plot development, character description, and connecting ideas and events. Scaled scores are meant to assess a child's comprehension irrespective of their age/reading level and range from 147 to 412. For grades 3 through 6, a score of 320 or higher is considered proficient (New York State Department of Education, 2015). The pretest reading achievement was measured with students' third grade 2015 New York State Reading Assessment (NYSRA) ELA scale score, the year prior to program implementation. With the use of the NYSRA ELA scale scores instead of the raw scores to measure reading achievement, the test results are standardized so that scores would have relative equivalence in terms of reading assessment even across grade levels (New York State Department of Education, 2014). State test data is both cost-effective and consistent as data for all schools is collected and can be used for large scale analyses. In addition, state tests represent what practitioners and policy makers care about most, so they have great face validity. Other measures such as gender, ethnicity, and eligibility for school lunch were also provided in the data but were not reported in this study because preliminary testing found that these covariates had no significant impact on reading outcomes.

Table 1
Frequencies and Percentages of Demographics Characteristics for Elementary School Students.

Gender	Treatment Schools, $N = 4$	
	n	%
Female	82	48.5
Male	87	51.5
Ethnicity		
Asian	4	2.4
Black	82	48.5
Hispanic	78	46.2
White	5	3.0

2.2.2. Survey

An online-survey was administered to 13 (F = 10) fourth grade teachers in treatment schools in spring 2016. With the exception of the first question, all items are 5 point Likert scales that prompt the respondents to identify their level of disagreement or agreement with the item.

2.2.3. Multilevel model

In this study, the dependent variable reading achievement was nested within students over repeated measures and students were nested within schools. To satisfy the assumption of independence of observations, clustering effects need to be modeled using a multi-level model (Raudenbush & Bryk, 2002). A linear mixed model (LMM) was conducted to control for these clustering effects and to compensate for inaccurate standard error estimates (Heck, Thomas, & Tabata, 2014; Norusis, 2012). For the level-1 model (the score level), the reading score (Y_{ij}) was the dependent variable of interest and the pretest-posttest was the predictor (*Year*) to assess the treatment effect from pretest to posttest. For the level-2 model (student level), only the random intercept for student was modeled to account for the variance of this cluster.

Level-1 model: $Y_{ij} = \beta_{0j} + \beta_{1i} Year + \varepsilon_{ij}$

Level-2 model: $\beta_{0j} = \gamma_{00} + u_{0j}$

Schools were not included in the model specification as a third level because of the low number of clusters ($N = 4$). Small cluster sizes in multi-level modeling are known to provide biased and error prone estimates of fixed and random effects in simulations (Maas & Hox, 2005). In a sensitivity analysis, a three level LMM model with school specified as a random third level effect was run with little to no difference in comparison to a two level model with time and student. In fixed effects, the estimate and significance of *Year* was unchanged and the covariance parameter of school was small (ICC = 0.036) and insignificant, $p = 0.408$. This linear mixed model approach was conducted in SPSS using the Restricted Maximum Likelihood (RML) estimation method to limit any issues with underestimated variance.

3. Results

3.1. Elementary school students: Reading scale scores

3.1.1. Reading score

The linear mixed model analysis results show a statistically significant difference in reading scores from pretest ($M = 284.53$, $SD = 30.82$) to posttest ($M = 295.57$, $SD = 27.45$), $p < 0.001$. The estimated mean difference between the two years indicated a 12.48 increase (*Std.* $\beta = 0.420$, Cohen's $d = 0.926$) in the reading scale score after treatment was implemented in these schools, $p < 0.001$. The relative model fit statistics are reported: log likelihood = 2946.96, *AIC* = 2950.96, *BIC* = 2958.49. Lastly, the intra-class correlation for student (*ICC* = 0.762) indicated that the effect of student explained 76.2% of the variation in reading scores. Table 2 presents the descriptive statistics of reading scale scores for elementary school students from pretest to posttest. Table 3 provides the linear mixed model coefficients of the intercept and time on reading scores for

Table 2
Descriptive Statistics of Reading Scale Scores for Elementary School Students from Pretest to Posttest.

Variable	Treatment Schools, $N = 4$		
	n	*M*	*SD*
Reading scale score			
Pretest	163	284.53	30.82
Posttest	158	295.57	27.45

elementary school students with 95% confidence intervals. Other measures such as gender, ethnicity, and eligibility for school lunch were also provided in the data but were not reported in this study because preliminary testing found that these covariates had no significant impact on reading outcomes, $p > 0.05$. Specifically, models with these covariates included found that none of them were statistically significant and they did not impact the mean difference from pretest to posttest significantly, $\beta = 12.46$.

3.2. Survey

Table 4 outlines standard deviations and means for survey items used to assess intervention fidelity. All items in the survey were measured utilizing a 5 point Likert scale that asked respondents to rate their answers in terms of frequency: "Less than once a week," 2 "1–2 times a week," 3 "3–4 times a week," 4 "Every day for less than 50% of instructional time," to 5 "Every day for more than 50% of instructional time," and in terms of agreement/disagreement: 1 "Strongly disagree," 2 "Disagree," 3 "Neither agree or disagree," 4 "Agree," to 5 "Strongly disagree". The results indicate that a majority of respondents (69.2%) answered that they implemented MDD program 1–2 times a week ($M = 1.85$, $SD = 0.56$). The participants tended to have strong agreement (mean responses ≥ 4.00) with: facilitating journal writing for exercises with the students ($M = 4.08$, $SD = 1.04$), overall teacher support of the goals of the program ($M = 4.08$, $SD = 1.12$), principal support of the program ($M = 4.15$, $SD = 1.07$), student enjoyment of the program ($M = 4.15$, $SD = 1.28$), and teacher belief that the program is effective in engaging the students ($M = 4.00$, $SD = 1.23$). Conversely, respondents showed less agreement (mean responses ≤ 3.00) with: having a hard time co-teaching parts of the program ($M = 2.54$, $SD = 1.13$), changing elements of the program to fit within their curriculum goals ($M = 2.92$, $SD = 0.95$), and that parents were actively involved in the program ($M = 2.92$, $SD = 0.64$). These results suggest that implementation of the program itself did not present many challenges for the teachers (mean responses > 3.00) with the sole exception of teachers changing elements of the program to blend with their curriculum objectives. However, this indicates overall adequate program fidelity. In addition, based on teacher perceptions the program has strong stakeholder support/engagement on the part of students, teachers and administrators but lacks strong stakeholder engagement on the part of parents.

4. Conclusion

The current study provides a practical, and effective approach for using embodied cognition that could be broadly replicated in any class. In relation to ESSA, the U.S. Department of Education deems an activity, strategy, or intervention as "evidence-based" when an evaluation demonstrates a statistically significant effect on student outcomes. In the present study, a single cohort was evaluated as 3rd graders in the 2014–2015 school year on reading scale scores and again as 4th graders in the 2015–2016 school year. The intervention was implemented in the 2015–2016 school year. The dependent variable (posttest) was students' fourth grade reading achievement measured by the 2016 New York State Reading Assessment (NYSRA) English Language Arts (ELA) scale score. The pretest reading achievement was measured with students' third grade 2015 New York State Reading Assessment (NYSRA) ELA scale score, the year prior to program implementation. According to the WWC Standards Handbook Version 3.0 (WWC, 2014, p.16), some requirements for outcome measures include "(a) demonstrate face validity and reliability, and (b) not be over-aligned with the intervention." The outcome measures included in the current evaluation of MDD clearly meet these standards. State test data has been proven to be cost-effective, and represents what practitioners and policy makers care about most, so it has great face validity. The achievement results reveal a statistically significant difference in reading scores from pretest to posttest for treatment students. The estimated mean difference between the pre- and posttests indicated an increase in the reading scale score after treatment was implemented in the schools.

The study results indicate that an embodied cognition approach to learning does have substantive associations with student achievement reading outcomes. This study's findings mirror the findings in Fischer et al., 2011 that establish a link between embodied cognition and academic achievement, specifically in reading in this case. This link can be explained in terms of theory through the MMD program's approach of utilizing motor memory exercises, automaticity, and motivational influence. Specifically, it's likely that the combination of memory building and reflective practice exercises in addition to journal writing and group discussions help to refine a participant's conceptual understanding of reading. In terms of motivational influence, it is apparent from the fidelity survey that the program keeps the children engaged in the process and this likely translates into greater engagement in learning.

With regard to fidelity of implementation, the highest mean responses were for the items: "I facilitate students' journal writing," and "Students seem to enjoy the program." It is notable that among the lowest mean responses was the item, "Parents are actively involved in this program." Drawing on Bronfenbrenner's (1977) ecological systems theory, child development is embedded within a framework of inter-related interactions, such as child-parent, child-teacher, and child-child dyadic relationships. Interventions may prove to be more effective and maintain lasting long-term effects when they embrace both school and family elements rather than either of them in isolation (Corcoran, 2017b; Powell, 2006). Following this logic, intervention programs need to include all school staff (Pianta, Barnett, Burchinal, & Thornburg, 2009), in addition to teachers and parents in order to have a substantive impact on family involvement and the child's education. Student academic success is elevated and this success has longevity when programs include classroom/school, teacher, and home components. Future directions should focus on using this survey to

Table 3
Linear Mixed Model Coefficients for Reading Scale Scores for Elementary School Students from Pretest to Posttest.

Reading score	Unstandardized		*t*	*p*	95% CI	
	β	*SE*			*LL*	*UL*
Constant	295.60	2.32	127.274	<0.001	291.02	300.18
Year	12.48	1.65	7.578	<0.001	9.22	15.73

Table 4
Means and Standard Deviations for Likert Scaled Survey Items.

Survey Items	*M*	*SD*	Skew
In the past month, how often did you implement MDD?	1.85	0.56	−0.14
I follow the steps on how to use this program as a co-teacher	3.46	1.05	-0.65
I facilitate students' journal writing	4.08	1.04	−2.29
I connect dance to my curriculum	3.38	1.12	−0.92
I develop lessons beyond the dance program	3.08	1.12	−0.17
I have a hard time co-teaching parts of this program	2.54	1.13	0.71
I feel like I am able to conduct the lessons effectively	3.46	1.13	−0.71
I have sufficient training on how to fit this program into my lessons outside of dance class	3.23	1.09	−0.53
I find the MDD professional development meetings useful	3.46	1.13	−0.71
I am confident that I implement this program correctly	3.31	1.11	−0.29
I change parts of the program to fit them into my curriculum goals	2.92	0.95	−0.51
I enjoy co-teaching this program.	3.77	1.24	−1.05
This program enhances my knowledge of dance related content.	3.54	1.27	−0.68
This program meets the needs of all or most of my students.	3.77	1.36	−0.91
I support the goals of this program.	4.08	1.12	−1.88
My principal provides the needed support (e.g., materials, training) for the program to be used properly.	4.15	1.07	−2.29
Parents are actively involved in this program.	2.92	0.64	0.05
Parents are supportive of this program.	3.54	0.88	−0.58
Students seem to enjoy the program.	4.15	1.28	−1.74
Students are on task for most of the time in the program.	3.92	1.19	−1.59
Students use thinking/reasoning skills in the program.	3.92	1.04	−1.94
The program is effective in engaging students.	4.00	1.23	−1.61

measure intervention fidelity in addition to developing a classroom fidelity score and to observe its relationship with classroom reading scores to assess a potential association. The small number of classroom teachers ($N = 13$) and the inability to link student reading scores by teacher in the data obviated this approach for this study.

There were several limitations of this study that require mentioning. First, a pre-post design without a comparison group was used for this study in order to examine the strength of the association between the intervention and outcomes. Consequently, this design did not impose randomization of subjects to groups at either the student or cluster (school) level. Therefore, there is a distinct possibility that the positive outcomes reported in this study were not necessarily the result of the intervention. This design limitation was partially mediated by accounting for previous reading assessment scores. However, more rigorous studies like experimental studies or quasi-experimental studies are needed to examine the *causal relationship* between outcomes and the intervention (What Works Clearinghouse, 2014). Second, there was a nonrandom selection of schools, and thereby students, in this design which increased the threat of selection bias. Selection bias can have a negative impact on the validity of a study's inferences because subjects are selected into the treatment group in a systematic way or for non-random reasons that lead to the treatment group sharing similar characteristics or outcomes that would not have occurred through a random process. This non-probability approach to subject selection also reduces the study to a convenience sample approach which requires considerable caution when generalizing the findings to the target population (Corcoran, 2017a,b). Last, the small number of teacher survey participants likely skewed the results, such that teacher mean responses would likely differ in large samples. Future fidelity research needs to emphasize recruiting additional participants across multiple schools to confirm that these fidelity results are replicable for this intervention.

Future research should include an impact and implementation study, conducted by an independent evaluator that provides quality implementation data in addition to student performance feedback (Corcoran, 2016). These sorts of studies provide crucial information for evaluating an intervention's success. Implementation studies should be well-designed, and should include (a) a well-specified logic model that specifies the key components of the intervention/program; (b) research questions linked to the logic model, including questions about the degree to which the implementation of the program mimics the program objectives as planned (fidelity of implementation); (c) plans for systematic, valid data collection; and (d) plans for how the data will be analyzed. These efforts would allow future researchers the opportunity to evaluate whether elements of program implementation are actually associated to the outcomes of the study. Further, in the present research study, a pre-post design is utilized. An obvious value of this design is substantial savings of cost. It does not, however, test the effects of MDD for improving educational outcomes in a randomized controlled trial design, which would be a valuable direction for further research.

This study illustrates the importance of measuring fidelity of implementation and fidelity of intervention. Implications for practice include careful consideration of the essential inputs and activities that can sustain quality programs and delivery, and involving the intermediary outcomes of the inputs. It is necessary to consider evidence on enactment of mediators (e.g., actual teacher behavior and knowledge, actual experiences of students). Further, including common teacher and student experiences across conditions in essential to understand the differences between treatment and comparison condition (i.e., treatment-control contrast). This concept is becoming increasingly important in the field as the aspect of implementation most closely tied to impacts since impact estimates represent the impact of the intervention being tested relative to the activities being implemented in the control/comparison sites (Hulleman & Cordray, 2009; O'Donnell, 2008). Understanding the difference can help develop an empirical explanation for the observed effect (or lack of effect) of an intervention. That is, small effects may be related to smaller-than-expected contrast between treatment and control conditions. For example, implementation of intervention in treatment group may be less than ideal, and/or some of key features of intervention may also be present in the control group. Measuring treatment-control contrast requires collecting comparable evidence on implementation in intervention and control groups and may involve adapting fidelity measures to apply to treatment and control. While valid and reliable measures may be difficult, time-consuming, and costly to develop and employ, such measures are proximal to effects, meaningful in impact analyses, and essential to understand the 'black box' of the intervention.

Funding

This study was funded by Mark DeGarmo & Dancers/Dynamic Forms Inc. (Grant 119477, R. P. Corcoran, Principal Investigator).

Acknowledgments

Thanks to the study participants and other personnel including: M. DeGarmo, Mark DeGarmo & Dancers/Dynamic Forms Inc.; J. Reilly, Johns Hopkins University; S. M. Ross, Johns Hopkins University; J. Smith, New York City Department of Education; R. Wilkins, University of North Carolina at Greensboro.

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