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Research paper

The effects of arts-integrated instruction on memory for science content☆

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ABSTRACT

Strong correlational evidence suggests that involvement in the arts improves students' academic outcomes and memory of learning events [1–3]. It is unclear whether the improved outcomes are the result of general exposure to the arts, the integration of arts into content instruction, the use of effective instructional practices, or a combination of these factors. Moreover, as a growing number of studies suggest that arts-integrated pedagogy enhances learning, few empirical studies have explicitly examined the direct effect of an arts-integrated curriculum on learning and specifically on students' memory for non-arts academic content. Thus, this study sought to determine the effects of arts-integrated lessons on long-term memory for science content. We hypothesized that embedding arts-based activities into conventionally taught lessons would produce learning outcomes as good as or better than traditional instruction. This paper describes the results of a randomized control trial that measured retention of science content using arts-integrated science units and matched units employing convention science instruction. The study was conducted in 16 fifth-grade classrooms in an urban mid-Atlantic school district.

1. Introduction

Memories associated with arts exposure are powerful—arts experiences are thought to elicit emotional cognition, employ creative thinking pathways, and recruit cognitive processes that inherently facilitate long-term recall. Strong correlational evidence suggests that involvement in the arts improves students' academic outcomes and memory of learning events [1–3]. Further, evidence from these studies indicates that using the arts as a pedagogical tool—known as arts integration—benefits struggling readers to a greater degree than proficient and advanced readers [4,5]. With growing evidence that arts education and arts integration have the potential to benefit learning in non-arts subjects, one might wonder why arts-integrated pedagogy is not practiced more widely. We argue that while teaching with and through the arts correlates with better learning outcomes, the research community has not provided adequate evidence through experimental trials that show the *direct* link between arts, content acquisition, and memory. Though the research provides evidence about the benefit of arts on engagement and other cognitive outcomes [6,7], the research on arts-integration and memory is scant.

In order to demonstrate to educators, policy makers, and education publishers the potential advantages of teaching with and through the arts, *causal* research is essential. State and local district leaders must be convinced that investment in any pedagogical changes and teacher training will reap positive outcomes for all learners. To our knowledge, our study is one of the few randomized control trials that explores the effects of arts-integrated pedagogy on students' memory for academic content. We offer our findings as the foundation for further studies on arts integration and the burgeoning platform for future policy change and new approaches to curriculum design for any content area.

1.1. Literature review and conceptual framework

In the following sections, we discuss how arts integration is described and outline the conceptual framework for our investigation of the effects of arts-integrated pedagogical methods on students' retention of academic content. We argue that, while arts-involvement is correlated with better student learning outcomes, the majority of the extant research involves quasi-experimental or correlational research designs, which leaves room to question causality of increased performance outcomes. Finally, in this section we outline our initial theory of change and provide evidence supporting the hypothesized effects of arts-integrated instruction on memory for non-arts academic content.

1.1.1. Arts education and arts integration

The variety of arts instructional methods and arts integration within

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education has been approached in several ways:

(a) art forms such as dance, drama, visual arts, or music are taught in discrete classes focused on students' acquisition of arts standards; (b) arts-based activities are employed as a means to teach other academic areas or concepts in non-arts content (e.g. shaping the body like a particular letter to enhance emerging literacy through dance or movement); or (c) the arts are used to reinforce academic concepts and make the content more engaging (e.g., using warm and cool colors when creating maps in science class) [1, p. 366].

Arts integration has also been described as promoting the effective transfer of knowledge and skills from arts to non-arts domains and to help students draw connections among different disciplines [8]. Specifically, Burnaford et al. [8] describe arts integration as: learning academic content with and through the arts to enhance learning outcomes; arts activities as a curricular connections process; and arts-infused learning as a way to foster collaborative engagement within a learning activity. A more recent definition delineates the process as a co-equal cognitive integration of the arts where "the arts are integrated with other aspects of the curriculum and students are required to use higher-order thinking skills and aesthetic qualities to gain further understanding of a particular academic concept" [2, p. 192]. For our study, we define arts integration as a pedagogical method for teaching non-arts academic content in which both non-arts and arts-based standards are addressed.

1.1.2. Arts integration and student learning outcomes

A plethora of research on the effects of arts education and arts-integrated pedagogy on student outcomes has been conducted over the past thirty years, but the majority of this literature largely examines the correlations between arts study (described as some type of involvement in the arts) and academic outcomes [9,6,10,11]. Within the smaller body of arts integration literature, evidence indicates that arts-integrated instruction correlates with higher levels of reading and mathematics achievement [2]. Most of these studies involve experimental or quasi-experimental designs in which the various factors that contribute to achievement may not be controlled. Still, it is important to examine findings involving arts integration at the whole-school level that show promise for improving student learning outcomes.

For example, in a three-year quasi-experimental study of matched treatment ($N = 3$) and control ($N = 3$) schools, Peppler et al. [1] investigated the effects of arts-integrated English language arts (ELA) instruction on standardized ELA assessments. This study used the Learning and Achieving Through the Arts model, which provides three strands to arts-integrated programming: (a) instruction to promote art skills and language development for students, (b) in-depth professional development and coaching for non-arts teachers, and (c) supplementary activities to encourage whole school adoption of arts integration to buttress creative experiences in all classrooms. While baseline scores on the standardized test indicated that control schools included more students initially at the proficient level, treatment schools significantly increased the percentages of students in proficient categories (increases of 10–13%) compared to no increase in the students in the proficient ELA test categories (-3% to 0% change) in control schools. Further, the average increase in ELA proficiency among English-language learners from baseline was 15% across all three years of the study in the arts-integrated schools. While these results support the effectiveness of arts integration, the findings are limited because the data analyzed for the study were school-based scores and not individual student test data, where, if available, the intricacies of the intervention might be parsed further or where the impact of the intervention might be examined more closely [1].

Similarly, Scripps and Paradis [3] implemented a quasi-experimental study design examining the effects of arts-focused schools versus academic-focused schools to determine the causal links between arts integration experiences, teacher professional development concerning arts integration, and student academic and arts outcomes. Students in the arts-focused programs outperformed students in paired academic-focused schools on arts-based assessments and standardized tests; academic-focused schools' pre- and post-academic scores remained fixed. In addition, low performing students in the arts-integrated schools largely reached the achievement of their average and high performing peers; a statistically significant difference in scores no longer existed. These findings suggest that applications of arts-based interventions may have a more powerful impact on academic outcomes for students from low-performing groups than students from proficient and advanced groups.

In a recent meta-analysis of arts integration studies, Robinson [2] evaluated 453 studies of arts integration to examine the effects of arts integration on low SES students' outcomes. Forty-four studies met the criteria for examining arts integration as a method to promote knowledge and skill in content areas and, in addition, influenced domains of cognition and motivation. Results indicated that arts integration, especially the use of multiple arts forms, had positive effects on reading achievement for populations of high-need students. There was also positive correlational evidence of the benefits of multi-arts integration on mathematics achievement, creativity/critical thinking, self-efficacy, motivation, cooperation, and student engagement. Along with the previously reviewed studies, this meta-analysis lends support for the possibility that arts integration improves student learning and broader cognitive domains such as creative thinking and problem-solving. These studies also begin to point to arts-integration as a possible tool for improving the achievement gaps between the lowest-performing students and their proficient and advanced peers.

1.1.3. Arts integration and memory

While these studies suggest correlational evidence that involvement in the arts improves students' academic outcomes [e.g. 1–3], it is not clear whether the improved outcomes are the result of arts exposure, integrating the arts into content instruction, strong teacher beliefs and practices, or a combination of these factors. Moreover, few empirical studies have explicitly examined the effect of arts integration methods on students' memory for non-arts academic content through pre-, post-, and delayed content-based assessments specifically designed for the study [12]. Recent theoretical papers and studies on arts integration support the theory of enhanced memory when students learn non-arts content through arts-integrated pedagogy.

For example, Hardiman [13–15] and Rinne et al. [16] describe the potential cognitive benefits of the arts on long-term learning. Rinne et al. [16] delineate a theory of change related to the effect of arts integration on students' retention of non-arts academic content. Arts integration pedagogical methods use multiple modes of learning that allow students to engage in learning activities unlike traditional curricular methods. To that end, the authors discuss the cognitive science underpinnings of the benefits of (a) rehearsal (e.g., the repetition of content through song or rap); (b) elaboration (e.g., drawing an example of known content); (c) generation (e.g., dramatizing an interaction between two famous scientists); (d) enactment (e.g., demonstrating states of matter with one's body); (e) oral production (e.g. singing the movements of the Earth); (f) effort after meaning (e.g., deciphering artistic renderings of the solar system); (g) emotional arousal (e.g., imagining the wonder of a first look through a telescope for early astronomers); and (h) pictorial representation (e.g., examining different artistic renderings of plant cells). Taken together, the authors argue that these "memory effects" are naturally recruited through the arts. Thus, this conceptual framework describes how arts integration methods use research-based, memory-enhancing activities to potentially improve memory for non-arts content [see 5].

Based upon the framework, Hardiman et al. [5] conducted a study of arts-integrated methods on memory for science content in one mid-Atlantic school within four fifth-grade classrooms using a randomized control experimental design. Curriculum specialists developed science units in the topics of Astronomy and Environmental Science using arts-

integrated activities for the treatment units and conventional instruction for the control units. Unit pairs were matched so that they provided the same science content, the same dosage of each content component, and the same mode of delivery to assure active learning experiences in both conditions. Pre-, post-, and delayed post-test data were collected using curriculum-based assessments designed to examine the retention of content taught in the units. Results indicated that arts-integrated instruction produced a statistically significant difference overall for memory of science content ($p = 0.012$). The driver of this outcome was a strong statistically significant effect for students reading at the lowest levels of reading achievement ($p = 0.009$). Using scores from the annual state assessment to determine reading performance, data showed that students scoring at the basic level benefitted the most from art-integrated instruction compared to peers performing at the proficient and advanced reading levels. The limitations of this study included using curricular materials that were not scripted, which led to variability in implementation fidelity. These findings corroborate Scripp and Paradis' [3] results suggesting that students who perform at lower levels of reading achievement may benefit more from arts-integrated methods than their higher-performing peers.

As few empirical studies have explicitly examined the direct effect of an arts-integrated curriculum on learning and specifically on students' memory for non-arts academic content, this study sought to further explore the effects of arts-integrated lessons on long-term memory for science content with an expanded study across multiple schools. We hypothesized that embedding arts-based activities into conventionally taught lessons would produce learning outcomes as good as or better than traditional instruction.

1.2. Initial rationale/purpose

The purpose of this study was to apply a randomized control design to arts-integrated pedagogy, missing from the quasi-experimental studies described above [i.e., 1,3], to draw causal relationships between arts-integrated instruction and content performance outcomes. The study of Hardiman et al. [5] begins to identify causal evidence suggesting that arts-integrated methods impact long-term memory of non-arts content. In our current study, we built from these findings through a randomized control trial using a larger sample size and controlling for fidelity of implementation by scripting all content into teacher guide books. Therefore, with more stringent controls into our research design, we sought to determine the effects of arts-integrated pedagogy on memory for science content.

2. Material and methods

2.1. Participants

Student participants. A total of 350 students from 16 fifth grade classrooms across six schools were eligible to participate. Two schools had four fifth grade classrooms, and four schools had two fifth grade classrooms each. Students at each school were randomized into one of two classroom pairs to receive instruction.

Teacher participants. All eleven teachers were certified, rated as highly qualified, and each teacher had served at least two years in their school prior to this study.

2.2. Setting

This study took place in a school district located in the mid-Atlantic region of the United States. The district enrolls approximately 85,000 students in grades preKindergarten through grade 12, 83% African-American, 84% low income based on Free and Reduced Meal Services, includes 186 schools, and has a budget of $1.34 billion. Schools were selected to participate based on the number of fifth grade classrooms. In order to be included in the study, each school needed at least two fifth grade classrooms or four fifth grade classrooms to allow for matching.

2.3. Design

This study was designed as a randomized control trial with randomly assigned equivalent control groups with condition reversal for the second unit of curriculum. We randomized at the student level by using a random number generator and placed students in one of two treatment conditions, either arts-integrated science or conventional science, for the first session of the study. Classroom pairs were matched within sites to create a balanced design controlling for time of day, within teacher effects, and order of the treatment. All teachers delivered both arts-integrated and conventional instruction. Each participant was exposed to both arts-integrated and conventional science instruction. Each science unit was taught over the course of 3–4 weeks during the fall 2013 semester, and this length of time is defined as a "session." The study was implemented for two sessions to ensure that participants experienced both control and treatment conditions. Students were randomly assigned to treatment and control groups for the first unit of study in the first session of this project. In the second session of the study, the participants stayed in their randomized groups and received the opposite treatment condition for a second science unit. For example, a student who was randomly assigned to conventional Astronomy in session 1 received arts-integrated Life Science in session 2. Student IEP designations were examined to ensure that the students with Individualized Educational Plans (IEPs) were evenly distributed across the classes, which they were. In the second session of the study, students stayed in their randomized class assignments and experienced a second science unit in the alternate treatment condition. There were three testing phases of pre-test, post-test, and delayed post-test.

2.4. Independent variable

Arts-integrated curriculum involved teacher delivery of curricular content and student demonstration of knowledge of content through visual and performing arts. The research team developed four treatment units that use arts-integrated instructional strategies in four different science topics and four control units matched in content that use conventional instruction. In order to control for potential confounding factors, we closely matched the treatment and control units in terms of content, dosage (the amount of time for content delivery for each activity across treatment and control conditions), order of content presentation, and type of instructional activity (e.g., group, individual, paired). Curriculum writers designing the units were careful to develop activities in both conditions that adhered to those matching requirements. While some of the activities were the same in both conditions, the control condition mostly involved conventional teacher-directed instruction through presentations, videos, PowerPoint presentations, and textual readings. Students demonstrated acquisition of content through oral and written activities. In the treatment condition, teacher presentations often used art forms to convey the concept and students displayed understanding by engaging in a variety of visual and performing arts.

The following examples describe the differences between conditions: In the control condition, students displayed knowledge by completing a chart or presenting the information orally, whereas in the arts-integrated treatment condition they displayed knowledge through a variety of arts-based activities such as dance, tableaux, singing, or drawing. In the control condition, students expanded on their understanding of vocabulary by writing a sentence using the target word, whereas in treatment they demonstrated their understanding of the vocabulary by taking visual notes, which entailed drawing sketches and writing notes. To reinforce content, students in the control condition engaged in choral reading of specific passages; in the treatment condition, they sang a song or a chanted a rap. Essentially, we designed conventional lessons to match the modality of presentation of the arts-

integrated lessons and the modality of student products. For example, instead of displaying knowledge by designing a collage of living and non-living things, students in the conventional conditional categorized living and non-living things in a simple chart. Students in both conditions displayed their knowledge through categorization of living and non-living things with a final product on paper, but the conventional condition student product was a traditional chart whereas the arts-integrated student product was a categorized collage. In conventional lessons, choral reading of a science text utilizes the same modality as singing, oral production of words while reading the words, but choral reading excludes the artistic factors of tonality, tune, and rhythm. A read-aloud, aka choral reading, of a science text does not include any arts-based activities, which is why we used this matched-modality activity for the delivery of content for conventional lessons when songs were utilized in the arts-integrated condition.

The topics of the four-unit pairs for this study are Astronomy, Life Science, Chemistry, and Environmental Science. Astronomy and Environmental Science were revised units, and Chemistry and Life Science were new units developed for this study. The pairs of science units included one revised unit and one new unit; Astronomy was paired with Life Science, and Environmental Science was paired with Chemistry. Each unit covered 15 days of instruction; each of the 15 lessons included standards based on the Next Generation Science Standards as well as Common Core State Standards. The unit format followed the 5E Learning Cycle model (*Engage, Explore, Explain, Elaborate, and Evaluate*) [17]. The units included overarching goals using a graphic organizer/concept map for each unit, instructional objectives, vocabulary, and activities for each of the components of the 5E Learning Cycle model. The software Adobe InDesign was used for lesson templates, which allowed for color-coding general instructions to teachers, scripted teacher presentation language, and desired student responses. The lessons were scripted to promote consistency in content and instructional delivery. Based on experiences with the preliminary study, the research team believed that scripting the lessons was an important component of the unit design, as some elementary teachers expressed a lack of confidence in their knowledge of science content and in effectively executing science activities. Teachers were asked not to read from the script but instead to carefully review the lessons so that they could deliver them in a natural way.

For each unit, teachers received lesson plan guide books, student workbooks, and all materials that were needed to deliver the science and the arts-based activities. If necessary, laptop computers and other supplementary electronic media, including PowerPoint presentations, videos, and music were provided.

2.5. Dependent variables

2.5.1. Curriculum-based assessments

The research team identified key content for items for curriculum-based assessments in the four content areas and developed pre-, post-, and delayed post-tests. The tests consisted of 30 items in a multiple-choice format with four possible responses. The team created three versions of each assessment for pre/post/delayed testing by changing question wording or modifying the order of answer choices. The measures were deliberately designed to be difficult, both to avoid ceiling effects and make retention challenging.

After completion of the study, posttest content assessment responses were examined to identify item difficulty. Any item that received less than 10% correct responses was dropped from the test pool across testing times. No items were dropped from the Astronomy assessment, seven items were deleted from the Life Sciences assessment, one item was deleted from the Chemistry assessment, and four items were dropped from the Environmental Science assessment. All students' scores were standardized to z-scores to equate scores for analyses.

2.5.2. Fidelity of implementation checklists

Fidelity of implementation checklists were designed based on recommended best practices as outlined in O'Donnell [18] and Nelson et al. [19]. The four areas included: (a) Exposure – The degree to which students are "exposed to" or receiving the treatment or control; (b) Adherence – The degree to which the teacher is implementing the lessons as written; (c) Participant responsiveness – The degree to which students are participating in the lesson activities; and (d) Quality of delivery – The degree to which the teacher demonstrates that he/she is prepared to teach the lesson (e.g. presentation of lesson is not read directly from script but taught in a natural way and all materials are prepared and ready when needed). A team of observers, trained to criterion, rated the four areas above on the following scale: 0 indicating no evidence; 1 indicating weak evidence; 2 indicating partial evidence; and 3 indicating strong evidence. A section titled "notes" was included for comments and evidence collected for each of the four areas. A final notes section asked observers to record any issues that may have arisen during the lesson delivery such as disruptions to instruction due to occurrences such as fire drills, public address announcements, or visitors to the classroom. They also noted any departures from delivering the lessons as written. For example, they noted content that may have been skipped or implemented in shorter or longer time periods than allocated. Observers were present in the classrooms from 40% to 60% of instructional time in both the treatment and control conditions.

Fidelity of implementation data indicated that teachers implemented lessons to fidelity at least 90% of the time during the observed lessons.

3. Materials

The research team reviewed each lesson in the eight units (60 lesson plans) to determine the materials that would be required to teach the science and arts-integrated activities in both the conventional and arts-integrated conditions. Materials lists were compiled and items purchased for 32 groups of students (approximately 360 students – 16 arts-integrated science kits and 16 conventional science kits) for science and arts-integrated activities. The research team recruited volunteers from area high schools and universities to create, assemble, and deliver materials kits to each study site school. The team reviewed the use of materials with study site teachers and observers during professional development sessions.

3.1. Procedure

Professional development for participants occurred several weeks before the start of the study in early fall of 2013. The professional development was designed to assure that study site teachers had appropriate command of science content for the units they would teach and with the arts activities that were integrated into the units. The teachers received ten hours of formal training, which consisted of reviewing the activities that were designed for each day of instruction for each condition. Additionally, the training included simulation activities for targeted arts-integrated activities and science experiments. The study site teachers received all materials at the training sessions and learned how the materials were to be used with specific activities. In addition to the formal professional development, members of the research team provided additional one-on-one coaching to individual study site teachers throughout the study as needed.

The first units of the study were implemented in 16 classrooms across six schools in early fall of 2013. Session 1 was the first 15-week unit implementation and session 2 the second 15-week unit implementation. For each content area in each session, half of the units were taught in the treatment condition and half in the control condition. For example, the Chemistry units were taught by four teachers; two who taught in the arts-integrated condition and two who taught in the control condition in session 1. In session 2, the teachers taught the

reversed condition to a different group of randomized students. This was done for all curricular units.

3.2. Analysis

To determine the effects of arts-integrated instruction on long-term retention of content, descriptive and central tendency statistics were employed examining the differences between arts-integrated and conventional instructional methods. The order of analyses were:

1. In the first analyses, we sought to determine whether arts-integrated instruction affected retention in all students across all units combined.
2. Next, we examined the effects of arts-integrated instruction at the different reading levels.
3. Then, we examined the treatment effects at the level of the unit pairs (Astronomy-Life Science and Chemistry-Environmental Science) alone and with the reading levels.
4. Finally, we investigated the effects of both the instructional methods and the order of instructional methods on the percent of retained content at the level of the unit pairs.

Long-term retention of science content was operationalized by determining the percentage of retained content. The following formula was utilized: ((Retained Content (T3) – Prior Knowledge (T1)) / (Initially Learned Content (T2) – Prior knowledge (T1))*100. This formula represents the percentage of science content that was retained over time while controlling for students' prior knowledge. For purposes of these exploratory analyses an alpha value of 0.10 was used.

4. Results

4.1. Arts-integrated instruction versus conventional instruction: all science units

Across all science units: A one-way analysis of variance was employed to examine the effects of different instructional methods on long-term retention of science content. The instructional methods factor included two different conditions: arts-integrated science instruction and conventional science instruction. Homogeneity of variance was upheld by Levene's test which indicated that the groups were not significantly different and were derived from the same population; $F(1, 508) = 0.146$, $p > 0.10$.

Results of the analysis indicated no statistically significant difference between percent of retained content in the arts-integrated instruction condition versus the conventional instruction condition ($M_{AI} = 64.22\%$, $M_C = 67.99\%$), $F(1, 508) = 0.128$, $p = 0.721$.

Across all science units and reading levels: In order to examine the effects of instructional methods on long-term retention, we added reading ability levels as a second factor to the ANOVA model. Using predetermined benchmarks from the state end of year assessment, three reading levels were identified as basic, proficient, and advanced. A 2 × 3 factorial analysis of variance was employed to inspect the effects of the instructional methods at the different reading levels (basic, proficient, advanced) on percent of retained content. Homogeneity of variance was upheld by Levene's test; $F(5, 475) = 5.2$, $p > 0.10$. Means and standard deviations are presented in Table 1. The value of 105% in Table 1 is an actual value. This value for Basic Readers in the Arts Integrated condition resulted from students demonstrating enhanced retained content on the followup testing (Retained Content T3) beyond what was initially demonstrated on the posttest (Initially Learned Content T2); please see the formula used for long-term retention at the end of the Section 2.

We found no significant difference between percent of retained content in the arts-integrated instruction condition versus the conventional instruction condition, $F(1, 475) = 2.101$, $p = 0.148$, nor between the reading levels, $F(2, 475) = 0.343$, $p = 0.710$. A statistically significant interaction effect was observed between instructional method and reading levels, $F(2, 475) = 3.570$, $p = 0.029$. Results of post hoc t-tests using Bonferroni comparisons for equal variances not assumed indicated basic readers remembered significantly more science content learned through the arts at the delayed post-test than basic readers who learned science through conventional methods (see Fig. 1).

Table 1
Mean percentages of retained content in the reading levels and instructional methods.

Reading level	Instructional method	*M*	*Variance*	*N*
Basic	Conventional	32.3%	172.7	30
	arts-integrated	105.8%	150.1	30
Proficient	Conventional	72.8%	125.5	123
	arts-integrated	69.0%	124.1	118
Advanced	Conventional	69.7%	63.8	89
	arts-integrated	53.7%	80.5	91

4.2. Arts-integrated instruction versus conventional instruction: unit pairs

Unit pairs: A 2 × 2 factorial analysis of variance was used to examine the effects of instructional method (arts-integrated and conventional) and unit-pairs (Astronomy-Life Science and Chemistry-Environmental Science) on mean percent of retained content. Homogeneity of variance was upheld by Levene's test which indicated that the four groups were not significantly different; $F(3, 506) = 3.195$, $p > 0.05$.

Findings of the factorial model revealed no statistically significant difference between percent of retained content in the arts-integrated instruction condition versus the conventional instruction condition ($M_{AI} = 64.22\%$, $M_C = 67.99\%$), $F(1, 506) = 0.094$, $p = 0.759$. For unit pairs, no statistically significant difference was observed on percent of content retained; ($M_{AS\text{-}LS} = 59.61\%$, $M_{CH\text{-}ES} = 73.78\%$), $F(1, 506) = 1.801$, $p = 0.180$. No interaction effect was observed between instructional method and unit pairs, $F(1, 506) = 0.275$, $p = 0.600$.

4.3. Arts-integrated instruction versus conventional instruction, unit pairs, and timing of instructional method

A 2 × 2 × 2 factorial analysis of variance was used to examine the effects of instructional method (arts-integrated and conventional), unit-pairs (Astronomy-Life Science and Chemistry-Environmental Science), and timing of the instructional method (Session 1 or Session 2) on mean percent of retained content. Homogeneity of variance was upheld by Levene's test which indicated that the four groups were not significantly different; $F(7, 502) = 2.02$, $p > 0.05$. Means and standard deviations are presented in Table 2.

Findings of a 2 × 2 × 2 factorial ANOVA revealed no statistically significant main effect between percent of retained content in the arts-integrated instruction condition versus the conventional instruction condition for the Chemistry-Environmental Science unit pair, $F(1, 502) = 1.516$, $p = 0.219$. No statistically significant main effect was found in the percent of retained content in the arts-integrated instruction condition versus the conventional instruction condition, $F(1 502) = 0.003$, $p = 0.954$. No statistically significant main effect of percent of retained content was found for timing of instructional method, $F(1, 502) = 0.907$, $p = 0.341$. A statistically significant interaction between Condition by Timing, $F(1, 502) = 3.091$, $p = 0.079$ was observed. This test explored whether students who took arts-integrated science in the first session remembered more science in the second session when they learned science through conventional lessons.

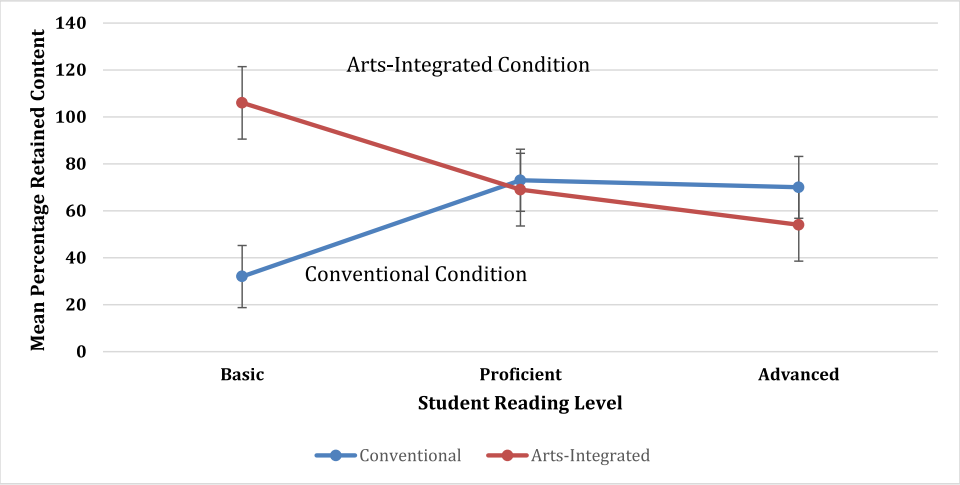

Fig. 1. Interaction of student reading level and study condition for retained content.
Note: circles represent mean values and wiskers standard deviations.

Table 2
Mean percentages of retained content between instructional methods and different sessions.

Timing	Instructional method	*M*	*Variance*	*N*
Session 1	Conventional	70.9%	105.4	142
	Arts-integrated	51.3%	122.7	135
Session 2	Conventional	64.3%	128.4	114
	Arts-integrated	78.9%	119.7	119

5. Discussion and conclusions

Overall, the hypotheses were confirmed. Specifically, the effect of arts-integrated instruction on long-term retention of content were:

1. Across all science units we found no significant difference between percent of retained content in the arts-integrated instruction condition compared to the conventional instruction condition.
2. We did find an effect of arts-integrated instruction at the different reading levels; basic readers remembered significantly more science content learned through the arts at the delayed post-test than basic readers who learned science through conventional methods.
3. We found no effect of arts-integrated instruction for different science units by student reading level.
4. Lastly, we found a treatment by order effect; students who took arts-integrated science in the first session remembered more science in the second session when they learned science through conventional lessons.

Using arts-integrated instruction to teach science content was as effective as or better than conventional science instruction in increasing long-term memory for students' science content knowledge. A combined analysis of all units in treatment and control conditions showed an advantage for arts-integrated instruction; statistically significant differences were found for struggling readers in the arts-integrated condition. This was not unexpected, as findings from previous studies [e.g. 1,3] suggest that only one year of exposure to arts-integration would not likely produce statistically detectable differences in academic outcomes.

5.1. Basic readers benefited the most

It is important to note that the results from this study mirrored the findings of Hardiman et al. [5] in that the groups of students reading at basic levels as measured by standardized reading assessments benefitted the most from arts-integrated instruction compared to proficient and advanced readers. We found significant differences in retention of science content in the arts-integrated condition compared to the control condition for this group of learners. Also, students reading in the proficient and advanced categories learned and remembered as much science in the arts-integrated units as they did in the conventional units. This finding is important because it begins to answer the question of whether teaching through the arts is as good as or better than teaching through conventional methods. We believe these findings indicate that it does and may address any teachers' concerns that students will learn less content if they employ arts-integrated instruction.

Achievement gaps have plagued our education system for decades [20]. Among the many categories of students that educators are charged with helping, teachers are asked to bring students at basic reading levels to proficient or advanced levels by the end of a school year, or at minimum, to move them forward by a year in their academic development [21,22]. Not only are teachers expected to improve reading, but also learning and memory in all subjects; struggling readers, however, often lag in the acquisition and retention of content knowledge. Students reading at the lowest levels of reading achievement often demonstrate lower performance in mathematics, science, and social studies. A primary challenge for these students is the requirement to "read to learn," when they are still in the process of "learning to read" [23]. Smith and O'Brien [24] found that providing cues to less-skilled readers to highlight global consistencies across information enhanced struggling readers' memory for content. Arts-integrated pedagogies and learning through the arts provides multiple cues in multiple modalities that allow students to conceptualize and access prior information, which is well-supported in cognitive science research on memory [16]. While research on enhancing memory, in general, for struggling readers is not widespread, we believe our line of research on learning through the arts can potentially offer another tool that might help struggling readers access their prior knowledge more readily, make connections to new information, and solidify memory for new content. We offer the findings of this second study as more evidence that learning through the arts might offer another vehicle for students with limited language or lower academic achievement to demonstrate mastery of academic content, perhaps as one more tool to close the achievement gap between struggling and proficient learners.

5.2. Possible transfer effect

Although not statistically significant, it is hard to ignore differences

in performance between the groups based on the timing of the units and the possibility of a transfer of skills. While all groups performed better on the second set of instructional units, students who were in the control condition in the first session seemed to perform at higher levels in the arts-integrated condition during the second session. Students who had arts-integrated instruction in the first session, however, seemed to perform just as well when in the control condition in the second session.

This leads us to wonder whether there may be transfer effects in which students may be applying creative problem-solving skills [15,25–28] and the acquisition of art skills and competencies to better understand and remember enduring ideas or big ideas [2,8,29,30]. Further, we hypothesize that students who learned science through the arts in the first session may have transferred some creative insights and arts competencies to their learning strategies within the conventional science lessons in the second session. At minimum, these findings call for further exploration into this potential phenomenon.

5.3. Implications for research and practice

This study supported findings from a preliminary study [5] with evidence suggesting that arts-integrated instruction is as effective as or better than conventional instruction for long-term memory of science content. Consistent with earlier findings, students performing at the lowest levels of reading achievement benefit the most from this pedagogical method. Further, we found that even though students at basic levels of reading learned less initially, they remembered more of what they learned. Recent studies have examined the relationship between individual arts training and memory, but not teaching non-arts subjects or topics through the arts [12].

While we found non-significant evidence that arts-integrated instruction may potentially produce a transfer effect after students have been exposed to arts integration first, further investigation is warranted to explore a possible treatment-by-order effect. This current study may not have had the power to detect the statistical differences between the groups. However, in practice, this potential transfer phenomenon is an important outcome to consider for teachers of science; students who took arts-integrated science in the first session remembered more science content in the second session when taught through conventional instructional methods. Although we exercise caution given non-significant findings, anecdotal evidence from study site teachers point to arts-integration as a useful tool for catalyzing transfer of skills between domains. It is also possible that an experimenter effect may have occurred in the study, since classroom teachers taught both the arts-integrated and conventional curricula. Clearly, this is an area for further investigation using a larger sample size and different teachers for conditions.

Additionally, we pose that future studies should further explore the effect of arts-integrated instruction on memory for content for students at lower levels of reading achievement. Presented with alternate and engaging ways to learn and demonstrate mastery of content through arts-integrated instruction, students who are experiencing challenges in reading acquisition may improve performance and engagement in learning. Exploring the efficacy of using the arts as a pedagogical tool could begin to shed light on how to address the performance gap that continues to challenge educators looking for viable and scalable solutions to differentiated instructional approaches. Moreover, we propose future studies to examine the extent to which potential variables of student self-efficacy and teacher efficacy mediate memory for content, creative problem-solving skills, arts skills, and conceptual competencies.

Also, one might wonder about the benefits of incorporating arts-integration if there are no statistical differences in memory for content for proficient and advanced readers. Research suggests, however, that there are additional benefits to integrating arts that are correlated with academic outcomes [6,24]. While some teachers might be resistant initially to the idea of arts integration [31,32], when presented with the evidence of correlated positive outcomes, teachers might be more likely to adopt arts-integrated instruction, especially if there are benefits for students who struggle with reading.

Lastly, we offer this study to the field as a potential model for examining the differences in the effects of a curricular or pedagogical intervention. Rarely are pedagogical interventions examined in randomized control trials in which each student receives exposure to both conditions over a long-enough duration of time to allow for detection of statistically and practically significant changes in outcome variables. Most studies examine interventions with comparisons only to “business as usual” models. While it was challenging to implement this study using tightly controlled treatment and control conditions, we found our participant teachers and their school leaders to be enthusiastic research partners in the study process. They expressed their deep interest in implementing both treatment and controls lessons to fidelity to explore the answers to these inquiry questions.

Finally, we hope that our findings will provide further evidence for educators, policy-makers, education entrepreneurs, and education advocates that arts-integration can provide another vehicle to support learning for all students, especially for the most vulnerable learners in our nation's schools.

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Conflicts of interest

None.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.tine.2019.02.002.

References

[1] K.A. Peppler, C.W. Powell, N. Thompson, J. Catterall, Positive impact of arts integration on student academic achievement in English language arts, Educ. Forum. 78 (2014) 364–377.
[2] H.R. Robinson, Arts integration and the success of disadvantaged students: a research evaluation, Arts Educ. Policy Rev. 114 (2013) 191–204.
[3] L. Scripps, L. Paradis, Embracing the burden of proof: new strategies for determining predictive links between arts integration teacher professional development, student arts learning, and student academic achievement outcomes, J. Learn. Arts. 10 (2014) 1–18.
[4] J.S. Catterall, The Arts and Achievement in At-Risk Youth: Findings from Four Longitudinal Studies, Research Report# 55, National Endowment for the Arts, 2012.
[5] M. Hardiman, L. Rinne, J. Yarmolinskaya, The effects of arts integration on long-term retention of academic content, Mind Brain Educ. 8 (2014) 144–148.
[6] A. Podlozny, Strengthening verbal skills through the use of classroom drama: a clear link, J. Aesthet. Educ. 34 (2000) 239–275.
[7] K. Smithrim, R. Upitis, Learning through the arts: lessons of engagement, Canad. J. Educ./Rev. Canad. Educ. 28 (2005) 109–127.
[8] G. Burnaford, S. Brown, J. Doherty, H.J. McLaughlin, Arts Integration Frameworks Research and Practice: A Literature Review, Arts Education Partnership, Washington, DC, 2007.
[9] R. Butzlaff, Can music be used to teach reading? J. Aesthet. Educ. 34 (2000) 167–178.
[10] K. Vaughn, E. Winner, SAT scores of students who study the arts: what we can and cannot conclude about the association, J. Aesthet. Educ 34 (2000) 77–89.
[11] E. Winner, M. Cooper, Mute those claims: no evidence (yet) for a causal link between arts study and academic achievement, J. Aesthetic Educat 34 (2000) 11–75.
[12] I. Roden, D. Grube, S. Bongard, G. Kreutz, Does music training enhance working memory performance? Findings from a quasi-experimental longitudinal study, Psychol. Music 42 (2014) 284–298.
[13] M.M. Hardiman, Connecting Brain Research with Effective Teaching: The Brain-

Targeted Teaching Model, Rowman Littlefield Education, Landam, MD, 2003.
[14] M.M. Hardiman, The creative-artistic brain, in: D. Sousa (Ed.), Mind, Brain, and Education: Neuroscience Implications for the Classroom, Solution Tree, Bloomington, 2010, pp. 226–246 IN.
[15] M.M. Hardiman, The Brain-Targeted Teaching Model for 21st-Century Schools, Corwin Press, Thousand Oaks, CA, 2012.
[16] L. Rinne, E. Gregory, J. Yarmolinskaya, M. Hardiman, Why arts integration improves long-term retention of content, Mind Brain Educ. 5 (2011) 89–96.
[17] R.W. Bybee, Science and Technology Education for the Elementary years: Frameworks for Curriculum and Instruction, Office of Educational Research and Improvement, Washington, DC, 1989.
[18] C.L. O'Donnell, Defining, conceptualizing, and measuring fidelity of implementation and its relationship to outcomes in K-12 curriculum intervention research, Rev. Educ. Res. 78 (2008) 33–84.
[19] M.C. Nelson, D.S. Cordray, C.S. Hulleman, C.L. Darrow, E.C Sommer, A procedure for assessing intervention fidelity in experiments testing educational and behavioral interventions, J. Behav. Health Serv. Res. 39 (2012) 374–396.
[20] J. Cassidy, E. Ortlieb, S. Grote-Garcia, Beyond the common core: examining 20 years of literacy priorities and their impact on struggling readers, Literacy Res. Instruct. 55 (2016) 91–104.
[21] B.D. Rampey, G.S. Dion, P.L. Donahue, NAEP 2008 Trends in Academic Progress, National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, DC, 2009.
[22] N.K. Scammacca, G. Roberts, S. Vaughn, K. Stuebing, A meta-analysis of interventions for struggling readers in grades 4–12: 1980–2011, J. Learn. Disabil. 48 (2015) 369–390.
[23] J.L. Adelson, E.R. Dickinson, B.C. Cunningham, Differences in the reading–mathematics relationship: a multi-grade, multi-year statewide examination, Learn. Indiv. Differ. 43 (2015) 118–123.
[24] E.R. Smith, E.J. O'Brien, Enhancing memory access for less skilled readers, Sci. Studies Read. 20 (2016) 421–435.
[25] K.N. Dunbar, Arts education, the brain, and language, in: C. Asbury, B. Rich (Eds.), Learning Arts and the Brain: The Dana Consortium Report on Arts and Cognition, The Dana Foundation, New York, 2008, pp. 81–92.
[26] E. Gregory, M. Hardiman, J. Yarmolinskaya, L. Rinne, C. Limb, Building creative thinking in the classroom: from research to practice, Int. J. Educ. Res. 62 (2013) 43–50.
[27] C.J. Limb, A.R. Braun, Neural substrates of spontaneous musical performance: an fMRI study of jazz improvisation, PLoS One 3 (2008) 1–9.
[28] R.K. Sawyer, Educating for innovation, Think. Skills Creat. 1 (2006) 41–48.
[29] The National Art Education Association, Authentic Connections: Interdisciplinary Work in the Arts, The National Art Education Association, Reston, Virginia, 2002.
[30] National Coalition for Core Arts Standards, National Core Arts Standards, State Education Agency Directors of Arts Education, Dover, Delaware, 2014.
[31] B.K. Lee, S. Cawthon, What predicts pre-service teacher use of arts-based pedagogies in the classroom? An analysis of the beliefs, values, and attitudes of pre-service teachers, J. Learn. Arts 11 (2015) 1–15.
[32] B. Oreck, The artistic and professional development of teachers: A study of teachers' attitudes toward and use of the arts in teaching, J. Teach. Educ. 55 (2004) 55–69.