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The Effects of Musical Ensembles-in-Residence on Elementary Students' Auditory Discrimination and Spatial Reasoning Skills: A Longitudinal Study

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Abstract

The purpose of this longitudinal project was to investigate the effects of a program combining musical ensembles-in-residence with regular classroom music instruction on elementary students' auditory discrimination and spatial intelligence scores. In combination with regular, sequential general music classes as part of their school curriculum, participants in the program received two half-hour lesson each week, from musical-ensembles-in-residence. These chamber ensembles provided aural models for reinforcing fundamental concepts for four consecutive years. Researchers collected data from a stratified, random sample of students in grades K-2 and 4-5 receiving the experimental program and demographically similar comparison schools, which did not receive any regular music instruction. A total of 684 elementary students in one school district in the southwestern United States served as participants in this study. Researchers found that the experimental program with the chamber music ensembles was associated with consistent and significantly ($p \leq 0.05$) greater scores in both auditory discrimination and spatial intelligence measures. Although these statistical results should be interpreted cautiously, implications for music education include promoting such an ensemble-in-residence program in conjunction with regular, sequential music instruction to benefit student learning. Future directions of this research include investigating the role of musically enriched school environments as a means of enhancing student learning.

Keywords: ensembles-in-residence, elementary music education, auditory discrimination, spatial intelligence

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Along with the other arts, music has a powerful and positive impact on student learning because it promotes creativity and higher-order thinking skills (Burton, Horowitz, & Abeles, 1999). Many educators regard music in particular as key to students' cognitive growth. In musical activities such as listening, singing, instrumental playing, and composing, students have demonstrated higher-order cognitive skills such as understanding, applying, analyzing, evaluating, and creating (Anderson et al., 2001). A host of researchers from neurology and cognitive psychology have investigated the relationship between music study and several other areas including academic ability, psychological and social abilities, and motor tasks (Cutietta, Hamann, & Walker, 1995). Several meta-analyses on the far-reaching effects of music instruction demonstrate a variety of extra-musical outcomes including spatial-temporal reasoning and auditory skills, among others (Hetland, 2000).

Considering these and other findings, it is clear that music instruction can reinforce and promote learning in other fields; what is uncertain is how to make the most of these linkages between music and the rest of the curriculum (Scripp, 2002). Because there is a need to advance scholars' understanding of music perception and cognition (Teachout, 2005) and because there is a, "critical need for research in the area of integration and arts-learning outcomes" (Barry, 2008, p. 33), researchers in the current study investigated the effects of a residential music education program. This experimental treatment featured ensembles-in-residence presenting lessons that emphasized links between music and other learning goals as an enhancement of the regular, weekly, sequential, general music instruction delivered by a music specialist. In particular, the purpose of the current, longitudinal study was to investigate the effects of this ensemble-in-residence program on elementary students' auditory discrimination and spatial reasoning skills.

Literature Review

Musical experiences in schools have a variety of wide-ranging impact on learners. In general, music and its instruction promote students' individual growth and foster positive psychosocial development (Cutietta et al., 1995). Teachers and administrators generally regard K – 12 music education classes as effective in both developing skills and knowledge specific to music performance and enriching learning in other subject areas. According to the National Association for Music Education (2012), additional benefits include creativity, communication, critical assessment, and commitment. In particular, music learning is linked to spatial-temporal reasoning in two distinct yet non-exclusive models (Hetland, 2000). Whether via near transfer, as proposed by Shaw (2003) or via the rhythm theory, as suggested by Parsons and Fox (1997), common sequential and spatial skills are integral to musical tasks (Bilhartz, Bruhn, & Olson, 2000). In addition, music listening is a prerequisite for musical pursuits and an essential component of every musical activity (Madsen & Madsen, 1998). Accordingly, general music educators now focus more attention on perceptive listening skills (Haack, 1990). They report making considerable progress by including analytical and perceptive listening activities and lessons in music series textbooks (Haack, 1992). For the purposes of this study, the researchers limited the scope of this investigation to these two important outcomes: spatial intelligence and auditory discrimination.

Spatial Intelligence

In a considerable number of studies related to music education, researchers have used measures of spatial-temporal reasoning as variables (Teachout, 2005). For example, in her 2000 meta-analysis of research literature addressing the relationship between music instruction and spatial intelligence, Hetland found that music instruction lasting two or more years and involving active music-making was associated with dramatic improvements in students' spatial-temporal reasoning. Her analysis included fifteen studies that met rigorous standards for inclusion. Not to be confused with the often-discredited "Mozart effect" involving passive music listening, Hetland's meta-analysis clearly targeted studies using active music making. This is an important distinction for the current study because the experimental program involved students in hands-on, dynamic activities as well as critical listening lessons. Hetland's findings are consistent with others in the literature, linking the effects of music instruction on spatial intelligence. Children who received instruction in general music, applied piano, and singing utilized spatial intelligence differently than students not receiving any music instruction (Rauscher, Shaw, & Ky, 1993; Hetland & Winner, 2001). Similarly, Bilharz, Bruhn, and Olson (2000) reported a statistically significant increase in spatial-temporal reasoning as a result of general music instruction among young children. With reference to the current study, none of these previous investigations included ensembles-in-residence as part of their instructional treatment.

As Teachout (2005) summarized, the results from previous investigations on the link between music learning and spatial reasoning are mixed. Some revealed statistically significant, positive results while others did not. During the same timeframe, other researchers (Gromko & Poorman, 1998; Rauscher, 2002; Rauscher & Zupan, 2000) reported a causal influence of music learning on spatial reasoning while using randomized participant selection. More specifically, Rauscher and Zupan studied the effect of classroom keyboard instruction on the spatial intelligence of kindergarten students. They found that the keyboard instruction was associated with statistically significant, positive differences on two of three subtests used to measure spatial-temporal reasoning. Therefore, researchers for the current study chose to investigate spatial reasoning skills using a stratified, random selection of participants in light of these inconsistent results and earlier success with randomized participant selection.

Auditory Discrimination

As an auditory phenomenon, music has an inherent and direct impact on listening skills. Considering sound as opposed to music *per se,* Menning, Roberts, and Pantev (2000) investigated listeners' ability to discriminate between pure tones. During a three-week training period, listeners incrementally improved their ability to distinguish between given tones. The researchers concluded that participants' brains underwent a change, modifying their neural pathways to recognize these tones. Such malleability of the human brain suggests that listeners, especially in the elementary grades, would improve their listening skills and ability to discriminate between different sounds. Bilharz et al. (2000) also associated increases in cognitive skills with musical growth. More specifically, they reported statistically significant improvement in rhythmic and pitch-matching skills among students receiving music instruction.

Similarly, Morrongiello (1992) considered the effect of formal musical training on students' auditory perceptions. She concluded that students displayed a growth in listening strategies to recognize specific tonal and rhythm patterns. Morrongiello underscored the need for understanding the mechanisms and effects of music listening experiences. Rauschecker (2001) provided one explanation in terms of brain plasticity. He wrote that, "Auditory experience changes the make-up of areas in the cerebral cortex that are involved in the processing of complex sounds, including music" (p. 330). He also reported that learning music in childhood is a particularly critical period during which the brain's plasticity allows it to reorganize itself.

One possible mechanism for enhancing listening skills is the level of complexity in listening experiences. Williamson (2005) investigated the level of attention as related to listeners' musical training and musical complexity. She found that the focus of attention on melody and harmony significantly increased as the level of musical training increased. Another possible avenue to enhance listening skills is critical thinking and higher-order cognitive processes. Johnson (2010) reported that music listening instruction in the music classroom resulted in statistically significantly greater responses from elementary-aged students. Through these means, music listening skills seem to be an important aspect of an interactive and experiential music curriculum.

As discussed above, previous investigations have studied the effect of music instruction on spatial intelligence and auditory discrimination in comparison to the lack of music instruction. None of those studies, however, involved ensembles-in-residence and only one was longitudinal in nature. While this related literature informs the current investigation, the current study offers new and valuable insights into the effects ensembles-in-residence may have over an extended timeframe.

Method

Research Design

For the current study, the experimental music program consisted of presentations delivered by ensembles-in-residence designed as co-curricular instruction with the elementary classroom teachers. This treatment was also developed in conjunction with regular, sequential general classroom music instruction. Because residency programs in schools offer more imaginative and interrelated lessons (Bresler, DeStefano, Feldman, & Garg, 2000), the researchers chose to focus on this element in the experimental treatment, thereby fostering intellectual curiosity and inquiry among the students. So as not to diminish the importance or role of the general music instruction, the researchers chose to integrate the ensemble presentations with the regular, general music classes, although this decision had the effect of confounding these two components. Researchers also chose spatial intelligence and auditory discrimination as dependent variables because of their connections to experiences in music education as reported by Hetland (2000) and Rauschecker (2001), respectively.

One additional feature of this research design was its longitudinal scope, which is often absent in literature on arts education (Catterall, Dumais, & Hampden-Thompson, 2012). For example, only 1% of all articles published by the *Journal of Research in Music Education* were longitudinal during the first thirty years of its existence (Yarbrough, 1984). On the topic of learning through the arts, one exception is a three-year study on a Canadian arts education approach by Smithrim and Upitis in 2005. Their project demonstrated a positive impact of arts education on computational skills among sixth graders. Therefore, the researchers chose a multi-year term for this study to this gain more in-depth insights into the efficacy of this program. With its four-year timeframe, the current study provides an important view into this type of education. It also begins to answer questions about the sustainability of learning outcomes among younger learners.

Participants

Participants were students in kindergarten through fifth grade attending public school in a medium-sized city in the southwestern United States. For this study, the researchers chose four local elementary schools to participate, based on their potential to benefit from this experimental program and the willingness of the principals to endorse it. All four experimental schools were urban, with a diverse racial mix and a substantial percentage of students receiving free or reduced-cost lunch. In these schools, the average racial mix was 37.7% white, 9.9% African-American, 44.8% Hispanic, 3.1% Native American, and 4.6% Asian American, while the average free or reduced lunch percentage was 75.4%, and the average stability (non-transient) rate was 82.4%. To serve as comparison schools, the researchers chose three schools that approximately matched the experimental schools in terms of racial diversity, percentage of students receiving a free lunch, stability rate, and similar urban settings. In those schools, the racial mix was 24.3% white, 9.9% African-American, 60.1% Hispanic, 3.6% Native American, and 2.2% Asian American, while the average free or reduced lunch percentage was 86.1%, and the average stability (non-transient) rate was 82.4%. The comparison schools received neither the experimental program nor general music instruction, but otherwise had the same academic curriculum. All schools used the same state and district-administered measures of academic quality.

During all four years of this study, kindergarten, first, and second grade students participated. Students in grades four and five joined this study for years three and four. A total of 684 students participated in this study. At the K-2 level, the experimental and comparison groups had 307 and 251 students, respectively. In the fourth and fifth grades, n = 126, distributed equally between the two groups. Schools offering the experimental program remained the same during all four years of this study. Therefore, kindergarten, first, and second grade students received three, two and one years of the experimental program, respectively, while fourth and fifth grade students received two and one years of the experimental program, respectively. Due to normal attendance variations and enrollment turnover, every student in each class did not participate in each test. To allow for more rigorous statistical procedures (Orcher, 2005) and as a parallel with previous related studies (Gromko & Poorman, 1998), the researchers analyzed a stratified random sample from both experimental and comparison schools. Using this method, the researchers were able to include some of the same students from year to year but maintained a stratified, randomized sample for each annual analysis.

The Ensembles-in-Residence Program

With the goal of enhancing the rest of the elementary classroom curriculum and emphasizing student-learning outcomes, the ensemble-in-residence program aimed to design and present coordinated, co-curricular lessons in conjunction with the elementary general classroom teachers and the general music specialist. During each of the four years of this program, one assigned musical ensemble-in-residence spent one hour per week in two half-hour blocks with individual classes at one grade level in each of the experimental schools. Program organizers made these assignments: a woodwind ensemble for kindergarten classes; two string quartets for kindergarten, fourth, and fifth-grade classes; and a vocal duo with a keyboard accompanist for first-grade classes. All musicians were employees of the school district, the local symphony orchestra, and/or the local university music department.

Traditional schooling limits thinking to one paradigm with its particular symbol system and vocabulary (Parsons, 1998). Instead, integrating the arts into the general classroom aims to make learning more meaningful. Alternatively known as interdisciplinary education, arts-centered curriculum, and integrated learning (Bresler, 1995; Jacobs, 1989), this type of instruction intends to connect ideas across subjects and highlight commonalities while noticing differences. Although there has been an increased interest on integrating music with other subject areas, such integrated learning often places music in a subservient role (Barry, 2008). Instead, the lessons for the experimental group in the current study used a co-curricular design to preserve the integrity of each discipline, as advocated by Snyder (1996).

As shown in the Lesson Plan Sheet in Appendix A, presenters collaborated with elementary classroom teachers and the general music specialist to design instruction that articulated music curriculum goals as well as co-curricular goals and objectives. Throughout the school year, the presenters and teachers communicated regularly about up-coming themes and lesson content while connecting their lesson content with the elementary classroom curriculum.

The program's resident musicians coordinated their sessions with the general classroom teachers and the general music specialist to enhance and reinforce terms and concepts taught in these classrooms. Using aural models, the musicians presented co-curricular topics including: counting, adding, differentiating same and different, phonetics, and other basic skills. Classroom experiences with the ensembles accounted for approximately 5% of the total annual instructional time. Students in the experimental schools also received regular music classes taught by a music specialist using a sequential music curriculum. These general music classes involved the students in active music making through experiences such as singing, instrument playing, movement, and focused listening. Each kindergarten general music class lasted a half hour, while general music classes at each of the other grade levels lasted forty-five minutes. In addition, students in each grade level received two half-hour lessons each week, presented by the ensembles-in-residence.

Assessment Measures

To measure the effect of the experimental program on participants' spatial intelligence and auditory discrimination skills, researchers and teachers administered multiple assessments to students in both the experimental and comparison schools near the end of each of each school year. The researchers speculated that participants receiving the experimental instruction would show increased spatial and aural abilities in contrast to students in the comparison schools.

To measure spatial intelligence, the researchers administered the *Test of Pictures/Forms/Letters/Numbers/ Spatial Orientation & Sequencing Skills* (Gardner, 1991) to kindergarten, first, and second-grade students from the experimental and comparison groups. The purpose of the spatial intelligence test was, "to determine a child's ability to visually perceive pictures, forms, letters, and numbers in the correct direction, and to visually perceive words with the letters in the correct sequence" (p. 13). The test, a traditional paper-and-pencil assessment, contained seven subtests: Spatial Relationships (Pictures), Spatial Relationship (Forms), Reversed Letters and Numbers, Reversed letters in Words, Reversed Letters from Non-Reversed Letters, Reversed Numbers from Non-Reversed Numbers, and Letter Sequencing. On the test, participants completed tasks such as circling letters or numbers that appeared backwards.

Intended for children in preschool through the third grade, this measure of spatial intelligence has published standardized norms and established reliability and validity. The reliability coefficients for sum scores are $r = 0.95$, 0.93, 0.89, and 0.85 for ages 5, 6, 7, and 8, respectively (Gardner, 1991). Researchers converted participant scores to standard scores using the norms provided with the testing instrument so that they could statistically compare students of different age levels. All scores were within one standard deviation of the national norms, indicating that the spatial intelligence subtests were appropriate for these students.

Because participants in the experimental group actively listened to and responded to live musical presentations for one hour per week in addition to listening activities in the general music classroom, the researchers hypothesized that participation in the program would increase students' aural discrimination abilities. To test this hypothesis, the researchers devised the following measure: they instructed the students to play aural games from the computer program *Making Music* (Subotnick, 1995) in kindergarten through grade two, and *Making More Music*

(Subotnick, 1997) in grades four and five.

To allow for a more robust statistical analysis, the researchers chose a stratified random sample of participants at each grade level (K-2, and 4-5) in both the experimental and comparison groups to play the game individually on a laptop computer, with a researcher seated by their side. In the two-part version of this game for K-2 grade levels, participants heard two short musical phrases and indicated whether the two phrases were, “Same or Different,” by clicking on the chosen answer. Differences could be in pitch, rhythm, or tempo. After choosing an answer, participants received immediate feedback from the computer in the form of either a crowd cheering (in response to a correct answer) or the friendly suggestion, “Oh well, try again” (in response to an incorrect answer). In the second, more advanced part of the K-2 measure, participants not only had to decide if the musical phrase was the same or different but had to identify or, “Name that Difference.” Participants indicated whether the second phrase was higher, lower, faster, slower, backwards, or the same as the first phrase. In the three-part version of this measure for fourth and fifth grades, participants first matched one of four examples to a given melody, then matched one of four rhythms to a given example, and finally matched a given musical phrase to one of four examples that was stylistically similar but not identical to the given phrase.

The researcher allowed each participant three examples before testing began in order to gain familiarity with the game. Then, the researcher allowed kindergarten, first, and second-grade participants ten trials on, “Same or Different” and six trials on, “Name that Difference.” Fourth and fifth-grade participants received six trials on matching melodies and rhythms, and four trials on matching styles. Without the student’s knowledge, the researchers recorded the number of correct responses as the participant’s score for each game. Maximum scores for participants in kindergarten through grade 2 were ten and six on, "Same or Different" and, "Name that Difference," respectively. The maximum scores for students in grades 4 and 5 were six, six, and four on matching melodies, rhythms, and styles, respectively. In pilot tests of these measures, the researchers determined that these numbers of trials were sufficient because additional repetitions of the games did not yield any different outcomes.

Results

Spatial Intelligence

For each year, the researchers performed comparisons of spatial intelligence scores using a series of one-way analyses of variance (ANOVAs). In years 1, 2, and 4, they found statistically significant ($p \leq 0.05$) differences in mean scores by group (experimental vs. comparison) on four of the seven subtests favoring the experimental group: Pictures and Reversed Words in year 1, Letter Sequencing in year 2, and Pictures and Forms in year 4. See Table 1 for a display of these results.

Table 1

Comparison of Standard Scores for Subtests of Spatial Intelligence by Group

Spatial Subtest	School Year	Group	N	Mean	S.D.	Significance Level
Pictures	Year 1	Experimental	59	102.5	12.7	0.03
		Comparison	38	93.8	26.3	
	Year 2	Experimental	80	99.6	13.6	Non-Significant
		Comparison	80	98.3	16.1	
	Year 3	Experimental	46	98.6	14.6	Non-Significant
		Comparison	43	97.9	15	
	Year 4	Experimental	50	103.5	13.1	0.004
		Comparison	27	93.8	15.1	
Forms	Year 1	Experimental	64	106.7	12.7	Non-Significant
		Comparison	38	101.7	14	
	Year 2	Experimental	80	105.8	11.2	Non-Significant
		Comparison	80	103.7	13.3	
	Year 3	Experimental	70	103.6	12.8	Non-Significant
		Comparison	70	103.3	9	
	Year 4	Experimental	93	104.4	11.9	0.013
		Comparison	63	99.4	12.9	
Reversed Letters 1	Year 1	Experimental	64	99.2	12.4	Non-Significant
		Comparison	37	96.2	14.4	

	Year 2	Experimental	80	95.8	12.1	Non-Significant
		Comparison	80	95	16.7	
	Year 3	Experimental	64	100.1	13.9	Non-Significant
		Comparison	63	99.5	15.7	
	Year 4	Experimental	72	100.5	14.5	Non-Significant
		Comparison	55	96.1	19.8	
Reversed Words	Year 1	Experimental	64	95.4	18.9	0.01
		Comparison	37	84.8	22.5	
	Year 2	Experimental	80	89.8	18.4	Non-Significant
		Comparison	80	86.9	24.9	
	Year 3	Experimental	70	88.6	22.6	Non-Significant
		Comparison	70	89.9	19.8	
	Year 4	Experimental	75	98.1	18.4	Non-Significant
		Comparison	57	93.9	19	
Reversed Letters 2	Year 1	Experimental	64	97.2	15.6	Non-Significant
		Comparison	31	97.6	23.9	
	Year 2	Experimental	80	96.8	16.5	Non-Significant
		Comparison	80	94.7	18.5	
	Year 3	Experimental	70	96.6	18.0	Non-Significant
		Comparison	70	98.6	14.5	
	Year 4	Experimental	88	96.7	17.2	Non-Significant
		Comparison	58	91.5	17.7	
Reversed Numbers	Year 1	Experimental	58	98.2	14.8	Non-Significant
		Comparison	30	92.4	23.3	
	Year 2	Experimental	80	95.6	15	Non-Significant
		Comparison	30	99.1	12.9	
	Year 3	Experimental	45	101.3	11.3	Non-Significant
		Comparison	41	102.3	12	
	Year 4	Experimental	45	102.7	13.6	Non-Significant
		Comparison	24	105.3	10.7	
Letter Sequencing	Year 1	Experimental	64	108.7	16.1	Non-Significant
		Comparison	30	103.3	19.2	
	Year 2	Experimental	64	109.4	11	0.04
		Comparison	30	104.3	18.2	
	Year 3	Experimental	67	102.5	18.2	Non-Significant
		Comparison	65	100.1	20.8	
	Year 4	Experimental	90	104.6	15.9	Non-Significant
		Comparison	61	101.9	15.7	

Because preschool boys typically have statistically, significantly higher spatial intelligence scores than girls (McGuinness & Morley, 1991), the researchers performed post-hoc analyses by gender on the spatial intelligence scores. In these, researchers used *t*-tests and found three statistically significant ($p \leq 0.05$) differences in mean scores by gender favoring girls. In year 3, the two differences were in Forms and in Numbers. For year 4, the difference was in the Reversed Letters 2 subtest. See Table 2 for a display of these results.

Table 2

T-test Comparisons of Standard Scores for Subtests of Spatial Intelligence among Kindergarten, First, and Second-Grade Students by Gender, year 3 and 4

Spatial Subtest		Gender	N	Mean	S.D.	Significance Level
Pictures	Year 3	Male	36	95.1	13.2	Non-Significant
		Female	43	100.2	16.3	
	Year 4	Male	42	100.4	13.4	Non-Significant
		Female	35	99.9	16.0	
Forms	Year 3	Male	36	100.4	12.7	0.04
		Female	43	106.3	11.6	
	Year 4	Male	82	102.3	12.1	Non-Significant
		Female	74	102.5	13	
Reversed Letters 1	Year 3	Male	36	100.6	12.7	Non-Significant
		Female	43	104.8	11.6	
	Year 4	Male	69	98.9	16.8	Non-Significant
		Female	58	98.3	17.5	
Reversed Words	Year 3	Male	36	94.1	13.3	Non-Significant
		Female	43	94.6	18.6	
	Year 4	Male	67	93.7	22	Non-Significant
		Female	65	99	14.3	
Reversed Letters 2	Year 3	Male	36	100.3	12.7	Non-Significant
		Female	43	104.7	12.4	
	Year 4	Male	75	91.9	17.8	0.04
		Female	71	97.6	17.0	
Numbers	Year 3	Male	36	98.8	12.7	0.02
		Female	43	104.7	10	
	Year 4	Male	36	102.7	12.9	Non-Significant
		Female	33	104.7	12.5	
Letter Sequencing	Year 3	Male	36	107	16.1	Non-Significant
		Female	43	108	15.7	
	Year 4	Male	78	103	15	Non-Significant
		Female	73	104.1	16.8	

Auditory Discrimination

To analyze for auditory discrimination, the researchers performed a series of t-tests for each year. They found that participants in the experimental group scored statistically, significantly higher ($p \leq 0.05$) than comparison students in all of the aural perception measures. In the first measure, "Same or Different," experimental participants statistically, significantly outperformed the comparison participants in years 2, 3, and 4. On the second measure "Name that Difference," experimental participants scored significantly higher in all years, with the exception of first-graders in year 1. Of the measures used only with the fourth- and fifth-grade participants, experimental participants statistically, significantly ($p \leq 0.05$) outperformed comparison participants in the "Matching Melodies" test in both year 3 and year 4. These same participants also outscored the comparison participants in the "Matching Rhythms" and "Matching Styles" tests in year 3. See Table 3 for a display of these results.

Table 3

T-test Comparisons of Aural Perception Scores by Group

Test	School Year	Grade	Group	N	Mean	S.D.	Significance Level
"Same or Different"	Year 1	Kindergarten	Experimental	36	7.64	1.47	Non-Significant
			Comparison	36	7.72	1.59	
		First Grade	Experimental	33	8.15	1.64	Non-Significant
			Comparison	32	7.88	1.26	
	Year 2	Kindergarten	Experimental	41	4.7	1	0.007
			Comparison	41	3.9	1.6	
		First Grade	Experimental	39	4.8	1.2	0.001
			Comparison	40	4	0.8	
	Year 3	Kindergarten	Experimental	35	4.9	0.8	0.001
			Comparison	35	4	1.3	
		First Grade	Experimental	28	5.2	0.7	0.001
			Comparison	28	3.9	1.1	
	Year 4	Kindergarten	Experimental	39	4.8	0.7	0.025
			Comparison	33	4.3	1.1	
		First Grade	Experimental	40	5	0.9	0.002
			Comparison	39	4.2	1.2	
"Name that Difference"	Year 1	Kindergarten	Experimental	36	4.17	1.46	0.02
			Comparison	36	3.44	1.16	
		First Grade	Experimental	33	4.33	1.22	Non-Significant
			Comparison	32	3.75	1.37	
	Year 2	Kindergarten	Experimental	41	5.9	2	0.0004
			Comparison	41	4.4	1.5	
		First Grade	Experimental	39	6.5	2.1	0.0001
			Comparison	40	4.6	2	
	Year 3	Kindergarten	Experimental	35	6.5	1.2	0.001
			Comparison	35	3.9	1.6	
		First Grade	Experimental	28	7.7	1.2	0.001
			Comparison	28	5	1.1	
	Year 4	Kindergarten	Experimental	39	5.9	1.8	0.004
			Comparison	33	4.7	1.8	
		First Grade	Experimental	40	7.1	1.6	0.0001
			Comparison	39	5.3	1.8	
Match Melodies	Year 3	4th & 5th Gr.	Experimental	23	5.7	0.6	0.001
			Comparison	23	4.9	1.2	
	Year 4	4th & 5th Gr.	Experimental	40	5.32	0.7	0.041
			Comparison	40	4.95	0.9	
Matching Rhythms	Year 3	4th & 5th Gr.	Experimental	23	5.4	0.7	0.03
			Comparison	23	4.8	1.1	
	Year 4	4th & 5th Gr.	Experimental	40	5	0.8	Non-Significant
			Comparison	40	4.9	1.1	
Matching Styles	Year 3	4th & 5th Gr.	Experimental	23	3.3	0.7	0.003
			Comparison	23	2.5	1	
	Year 4	4th & 5th Gr.	Experimental	40	2.7	1.03	Non-Significant
			Comparison	40	2.6	1.07	

Figures 1, 2, and 3 illustrate the longitudinal auditory discrimination data by test.

Figure 1. Kindergarten and First-Grade Students Auditory Discrimination Scores (Same or Different).

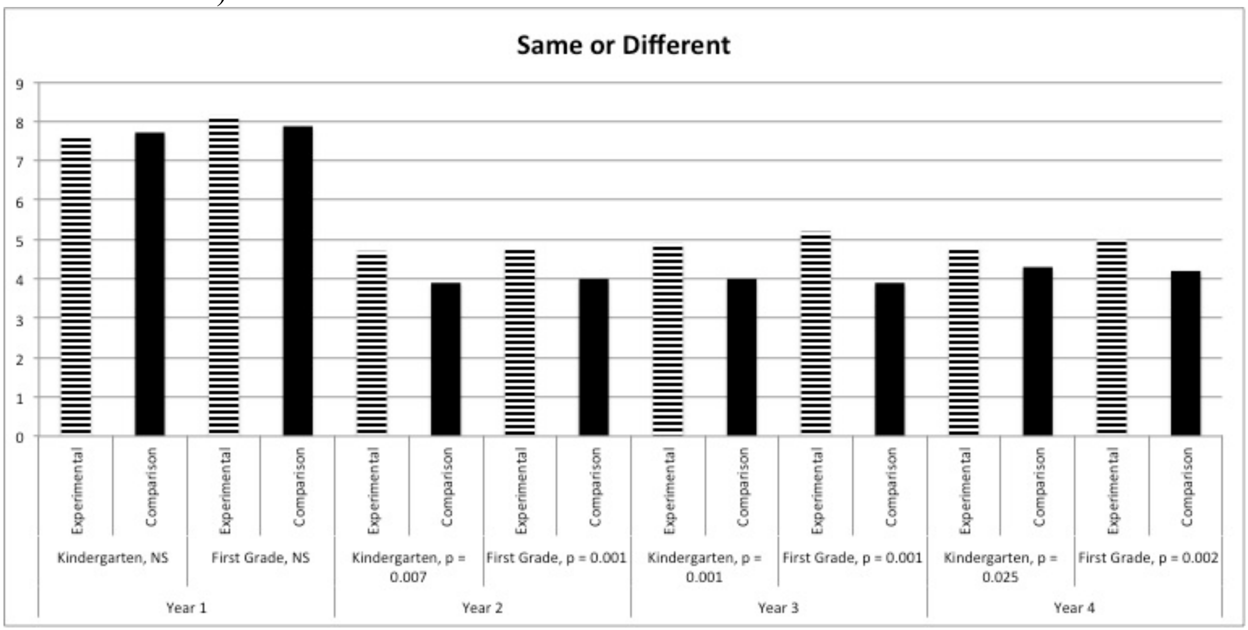


Figure 2. Kindergarten and First-Grade Students Auditory Discrimination Scores (Name that Difference).

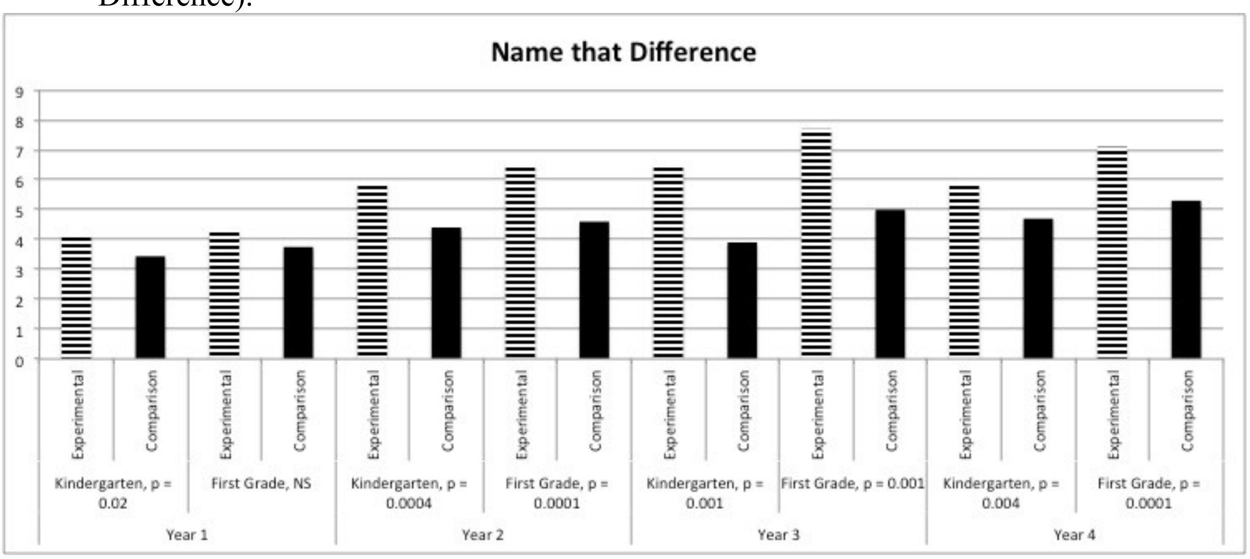
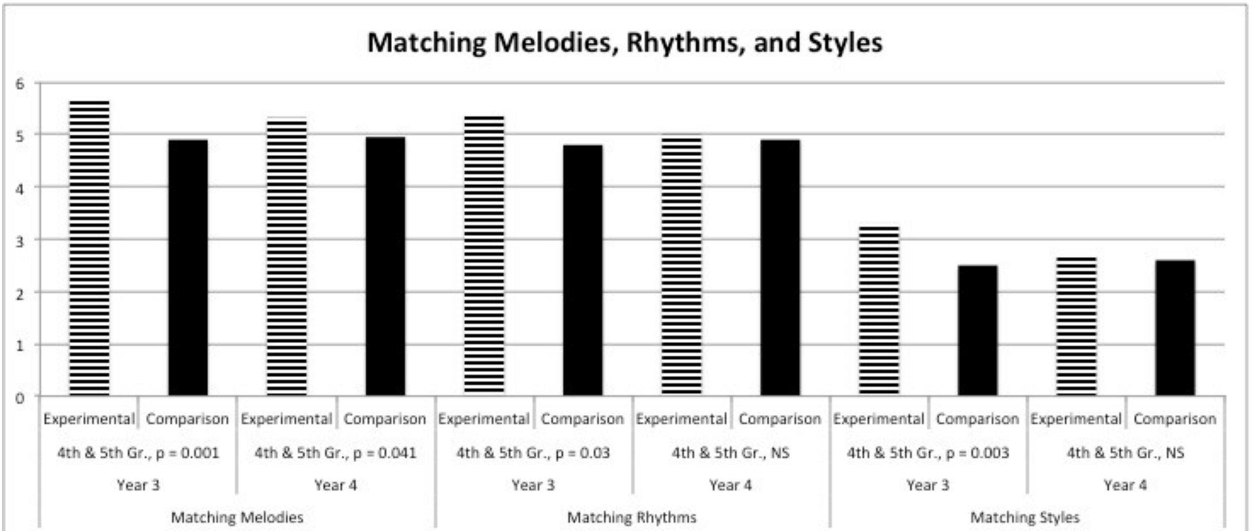


Figure 3. Fourth and Fifth-Grade Students Auditory Discrimination Scores (Matching Melodies, Rhythms, and Styles).



Discussion

Because music reinforces and promotes learning in other fields, musical experiences have the potential to enhance student achievement in those areas (Cutietta et al., 1995). One instructional strategy designed to make the most of this potential utilizes musical ensembles in residence and integrates student learning through music with the general education curriculum. For the current study, researchers investigated the effects of such a longitudinal ensemble-in-residence program as an experimental enhancement of the existing, sequential music instruction. During the four years of this study, they found that the experimental program presenting co-curricular classroom lessons made a statistically significant and positive impact on the learning and cognitive development of kindergarten through fifth-grade students as measured by their spatial intelligence scores and auditory discrimination skills.

More specifically, kindergarten through second grade students receiving the enhanced music instruction had statistically significantly higher spatial intelligence scores on most of the subtests than students in the comparison group. Mathematically, the experimental group out-performed the comparison group on 79% of the spatial intelligence measures. Although the statistical results should be interpreted cautiously, given the unequal number of participants between the groups, the results were evident in multiple subtests and consistent during the four years of this study. These results parallel the findings of other researchers (Bilharz et al., 2000; Rauscher et al.,1993; Hetland & Winner, 2001) and provide further evidence of the connection between musical experiences and other learning outcomes.

In addition to being consistent with earlier investigations promoting the positive impact of music instruction on spatial intelligence (Hetland, 2000), the current study offers additional information about this connection because it had a longitudinal scope and included featured ensembles-in-residence. More specifically, Bilharz and colleagues (2000) reported that the effect of group music instruction without ensembles-in-residence was limited to one subtest for abstract reasoning. Similarly, in 1993, Rauscher and colleagues reported a temporary elevation in one subtest for spatial reasoning among 36 participants after listening to ten minutes of a Mozart piano sonata. In contrast, researchers for the current study found that 370 experimental participants repeatedly demonstrated statistically, significantly higher scores on multiple subtests of spatial reasoning. Each school year, their treatment was one hour of weekly ensemble-in-residence sessions in conjunction with their regular, sequential general music instruction.

Post-hoc analyses in years 3 and 4 revealed that girls had statistically, significantly higher spatial intelligence scores than boys. Although these results are confounded with experimental vs. comparison grouping, they are inconsistent with those reported by Kerns and Berenbaum (1991), in a meta-analysis of spatial abilities (Voyer, Voyer, & Bryden, 1995), and with McGuinness and Morley (1991) who wrote that, without an intervention, there are statistically significant differences in preschool children's spatial abilities by gender favoring boys. Implications of these findings include fostering the spatial intelligence of all students in general, and girls in particular, with enhanced music-based experiences during kindergarten through second grade.

The results regarding auditory discrimination were more striking than those for spatial intelligence. In both the K-2 and the fourth and fifth grade levels, students in the experimental schools demonstrated statistically, significantly higher scores than did their comparison counterparts on every measure of aural discrimination in nearly every year of this study. More specifically, the experimental students were not only able to tell if a difference occurred in the music, but they were also able to identify the nature of the difference. In addition, the experimental group out-performed the comparison group on every subtest in every year except one. The researchers expected this result because the music teachers and ensembles-in-residence were encouraging the students to focus intently and to engage actively with music on a regular basis. This finding is consistent with Williamson (2005) and Johnson (2010) who indicated the benefits of enhancing music curricula in terms of students' listening skills and aural engagement.

As demonstrated by the fluctuating differences between experimental and comparison group scores during the four years of this study, experimental participants did not seem to accumulate increasing auditory skills or spatial intelligence. In other words, experimental participants did not accrue increased benefits as a result of the experimental instructional program. Perhaps the transient rate, 17.6% in both experimental and control schools, had the effect of minimizing any possible accrual of these benefits. Results from future studies with more stable student populations might provide researchers with comparison data to investigate possible accumulation of learning outcomes in more detail.

Although contact time with the ensembles-in-residence was minimal, approximately 5% of the total annual instructional time, the impact of the musical environment in the experimental schools on student learning was considerable. The experimental program had consistently positive and dramatic influences on students' spatial intelligence and aural perception. Students in the experimental group showed measurable benefits in musical and non-musical ways. The resident musical ensembles, when combined with the existing, sequential music education curriculum, delivered a coordinated, co-curricular music education program that resulted in significantly enhanced student learning.

The intent of this study was to explore the effect of an experimental, co-curricular music program in combination with the existing, sequential music education curriculum. Because the comparison group received neither the experimental music instruction nor regular music classes, the research design presents a limitation by confounding these two factors. Another limitation of this study was the lack of individual student tracking from year to year; if the researchers had been able to monitor the outcome measures for individual students, they would have been able to explore the longitudinal effects of this experimental program more closely. Statistical findings, therefore, should be interpreted with caution.

Directions for future study include addressing the study's limitations by separating the confounding variables of general music instruction and the ensembles-in-residence, and by tracking individual students to yield more specific data. In future, researchers could also fully explore the relationship between musical experiences and spatial intelligence, particularly with respect to gender-based differences and explore how closely aural perception and discrimination skills are linked to other forms of student learning. Researchers might also explore the impact of such a program on learners of different age/grade levels, from different ethnic backgrounds, and with different socio-economic status.

In conclusion, the results of this study demonstrate the effect of ensembles-in-residence collaborating with music and classroom teachers to present a co-curricular program. Students receiving this instruction had statistically, significantly higher spatial intelligence and auditory discrimination scores than comparison students. In other words, sequential music instruction, when enhanced by ensembles-in-residence, lead to statistically significant increases in student learning. In addition, this study contributes two unique features to the field of extra-musical learning in music education settings. It offers a longitudinal perspective on ensembles-in-residence as part of instructional curricula, as well an enhanced understanding of teaching and learning music. Implications include support and advocacy for other such residency programs in cooperation with regular, sequential classroom music instruction.

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Appendix

LESSON PLAN SHEET

Duration of Lesson:____________________Grade Level:_____Date: __________________

Music Curricular Connection as it relates to grade level curriculum (performance objective):

Goal: (tied to performance objective):

Materials:

Lesson description: ____

Introduction:____

Activity:____

Co-Curricular Integration (tied to objective):

Extension:

Teacher Comments:

Teacher Signature_________________________________

My next theme (unit) will be____________________start date______________________________

tied to________________state standard (classroom curriculum) _______________________

(list performance objectives):

Teachers: Please give artists specific information at least two weeks ahead of time so they can plan effectively tying their lessons directly to the classroom curriculum.

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