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ABSTRACT

Two studies examined the relationship between children's clay models and the children's concurrent school achievement, and compared a 6-year longitudinal record of achievement test scores for one cohort of students at schools that did or did not provide visual arts instruction. Participating in Study 1 were 201 kindergartners and third graders from 4 urban public schools matched on school characteristics and neighborhood demographics. Two schools offered some visual arts education supplementing basic skills instruction. One school emphasized arts learning including dance, drama, music, and visual arts. The fourth school did not provide any school arts program. Photographs of clay models were rated by 3 trained judges for 13 features such as height, shape, clarity, texture, and detailing. Ratings were compared between grade levels and visual arts emphasis in the schools. Nationally standardized student achievement scores on the Iowa Tests of Basic Skills were compared for art and non-art groups. Results indicated that art-trained children produced models more prominent in their degree of shaping, amount of detailing, and vertical position, but not expressive qualities. The art-trained, third grade models showed several significant positive correlations with standardized reading and math scores, which accounted for about 15 percent of total reading and math score variance. In Study 2, the Grade 6 reading scores for a 6-year longitudinal cohort of 414 children were examined and showed that art-trained children scored .63 standard deviation units above the overall mean. (The model rating scale is appended. Contains 98 references.) (Author/KB)

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LINKS BETWEEN CHILDREN'S CLAY MODELS AND SCHOOL ACHIEVEMENT

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Abstract

Clay models were collected from kindergartners and third graders in four urban public schools carefully matched on school characteristics and neighborhood demographics. Two of the schools offered some visual arts education but only as a supplement to their primary emphasis on learning "basic skills". Another school, however, put prominent emphasis on arts learning including dance, drama, and music, as well as the visual arts. A fourth school did not provide children any school arts program. The clay models were scored for 13 features and compared between grade levels and visual arts emphasis in the schools. Nationally standardized student achievement scores were then compared for art and nonart groups. The results showed, first, art-trained children produced models more prominent in several features including their degree of shaping, amount of detailing, vertical position, but not expressive qualities. Second, the art-trained, third grade models showed several significant positive correlations with standardized reading and math scores -- accounting for about 15 percent of the total reading and math score variance, respectively. An analysis of covariance of the Grade six reading scores for a six-year longitudinal cohort showed the art-trained children to score .63 standard deviation units above the overall mean.

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LINKS BETWEEN CLAY MODELS AND SCHOOL ACHIEVEMENT

Both researchers and philosophers have long contended that comprehending visual art, classical and contemporary, requires the viewer to manipulate concrete visual symbols, as well as their abstract referents, and form complex mental representations (Arnheim, 1969; Ecker, 1963; Gardner, 1982, 1983). Many researchers call this mode of cognition visual thinking and speculate it has relationships to problem solving and scientific thinking. Arnheim (1969, 1986) and Ecker (1963), in particular, emphasized relationships between visual arts experience and problem solving ability and their implications for intellectual development. Gardner (1983), also speculated that producing art involves manipulating symbols in a cognitive process related to language and higher-order thinking.

Purpose

Despite considerable speculation, the empirical support for contributions of visual art to cognitive development and school learning is surprisingly weak (but see Winner, 1988; Winner, Casey, Dasilva, & Hayes, 1991). Sound empirical evidence is especially lacking about the cognitive mechanisms that mediate visual and school learning. Consequently, the purpose of this research is to establish empirical relationships between visual arts background and school learning with the intention of better understanding their linkages with cognitive function. These relationships then provide the basis for speculating about the developmental dynamics that may underlie them.

The strategy for this investigation involved, first, identifying groups of children in kindergarten and Grade 3 who differ dramatically in their visual arts background. Then an authentic art sample was collected from each child that requires some obvious implementation of spatial ability such as a three dimensional clay model. In these models, a wide range of unique features was identified and statistically correlated with standardized measures of school learning. The resulting patterns of statistical correlations provided the evidence to infer linkages between visual arts experience during childhood and cognitive function. Finally, six year longitudinal school learning curves were compared for these groups who differed in visual arts backgrounds.

Background

Although researchers have found interesting relationships between visual arts background and cognitive development [2], their primary emphasis for most of the 20th century has been on trying to understand a progression of stages that appear in young children's human figure drawings [3]. Interpretations of this progression are common in the literature (Gardner, 1980; Golomb, 1992; Goodnow, 1977; Kellog, 1969; Luquet, 1913; see also Goodenough, 1926), and researchers claim it represents children's universal "search for meaning and likeness" (Golomb, 1981) and their "search for equivalencies" (Arnheim, 1954). Early studies of the close relationship between chronological age and drawing led researchers to believe this progression is related to intellectual maturity, and they based an IQ test (Draw-A-Man; Goodenough, 1926; Harris, 1963) on this pattern which continues to have wide clinical use (Lubin, Larsen, Matarazzo, & Seever, 1985). Most contemporary researchers, however, now question the validity of this progression for intellectual assessment (Chapman, 1978; May, 1989; Wilson & Wilson, 1981; for a review see Cox, 1993), and cross-cultural studies show this drawing progression is restricted to Western civilization, influenced by cultural values and education, as well as individual art background (Dennis, 1942; 1966; see Scott, 1981).

This progression in human figure drawing, however, is receiving renewed contemporary interest by cognitive psychologists, who show that, at least in part, it is related to children's working memory capacity (Bensur & Eliot, 1993; Dennis, 1991; Morra, Moizo, & Scopesi, 1988). Davis and Gardner (1993) present a contemporary perspective linking this progression to Piagetian and Vygotskian developmental perspectives.

Developmental psychology. Purported relationships between art background and cognitive ability do have substantial theoretical support. According to Piaget (Piaget & Inhelder, 1956; Piaget, Inhelder, & Szeminska, 1960/1981) children's conceptions of space and number, as well as many other cognitive functions, are related to figure perception which emerges from an infant's preoperational stage of development. According to this theoretical perspective, language development is largely the manifestation of an underlying symbolizing function that evolves from earlier cognitive development (Piaget, 1962; Werner & Kaplan, 1963).

A key mechanism underlying the Piagetian model of child development is the young child's construction of mental schemas to represent the perception of logical physical relations. Research is showing the accuracy of these schemas to increase as children physically mature and assimilate new experiences, and they have important implications for understanding the role of visual art during early childhood. Researchers, for example, have found early pretend-play schemas related to performance on cognitive-developmental tasks such as conservation (Golomb & Cornelius, 1977), and story content related to literacy development. (For an extended discussion of schema in story writing see Mandler, 1984; for early symbolism see Nicolich, 1977.) Consequently, contemporary developmental research supports basic Piagetian principles suggesting that early experiences such as producing visual art should influence and improve the effectiveness of children's emerging mental schemas.

A second developmental position with implications for the visual arts is provided by Vygotsky (1934/1986) who emphasized the cultural context of development, and the child's active role in constructing knowledge (Mason & Sinha, 1993). According to this perspective, interactions of children with peers and adults have central importance for development because they provide a social context that helps establish socially preferred methods of reasoning and desired modes of expression. Consequently, while children freely invent the means to manipulate the symbols of their native cultures, both to express needs and solve problems, the social context establishes boundaries. In this context, drawing fills an important role providing children an opportunity to experiment with symbol-making and expression culminating in written language. Not surprisingly, many researchers (Dyson, 1982; see also Brittain, 1979) believe that young children do not distinguish between early drawing and early writing linking both to children's emerging literacy skills and problem solving ability[4]. This perspective on children's symbolic inventions and their foundations for literacy has lead to speculation that children's art, language, and literacy depend on a common mechanism; the child's reflection (Vygotsky, 1962).

Cognitive psychology. Some of the newest and most profound evidence supporting relationships between early visual arts learning and cognitive development is provided by cognitive neuroscience. "Snowballing effect" (Kosslyn and Koenig, 1992) is a metaphor possibly describing the relationship between visual art and the developing brain. For example, early infant experiences (such as play activities or verbal interactions with parent) stimulate formation of neuropathways. The demands of these activities on the neurosystem establishes priorities for the order in which perceptual processes develop which has subsequent implications for the cerebellum's gradual hemispherical organization.

Cognitive science is also showing neurodevelopment during infancy and early childhood to be a time of substantial hemispherical plasticity (Kosslyn and Koenig, 1992; Witelson, 1977). Unlike earlier static models of brain organization that emphasized rigid hemispherical boundaries between genetically determined functions (left brain for verbal functions and right brain for visual matters) this research is showing that specific locations for brain functions overlap with each other depending on type of behavior (reading a book, walking across the room, and painting a picture all mobilize some common brain areas).

These advances in understanding the brain's basic development and organization provide insights into possible neuro-mechanisms mediating early visual arts experience and cognitive development. For example, children typically learn a simple activity like placing paper and pencil on a desktop first in the right hemisphere as physical-spatial rules in a system of vertical and horizontal coordinates (Koenig, Reiss, Kosslyn, 1990). With practice, however, the child transforms this spatial information into verbal code and stores it in the left hemisphere. Consequently, the first experiences of young children in a drawing activity stimulate visual-motor and spatial abilities primarily in the right hemisphere, but as children gain mastery over the physical process of drawing, this activity stimulates linguistic and semantic centers in the left. Contemporary research is suggesting that early drawing in conjunction with verbal interaction (discussing the content of a drawing with a teacher, creating a story to accompany a drawing, and so on) has an even greater effect on development (Pellegrini, 1985a, 1985b; Pellegrini & Galda, 1991). Speculation suggests that drawing and talking put substantially greater demands on mental coordination of physical verbal, and linguistic centers. (For many children, drawing and talking is their first attempt to coordinate a broad array of physical, symbolic, and semiotic neuroprocessing centers.)

Cognitive psychology is providing further insight into a key mechanism underlying general artistic development, the formation of mental images. Paivio (1971, 1978, 1983, 1986, 1989; see also Kosslyn, 1975, 1994) provides a theoretical perspective dividing neurological functioning into "two functionally independent but partially interconnected symbolic systems, a verbal system that is specialized for dealing with linguistic stimuli and . . . a nonverbal system specialized for . . . imagery" (1989, p. 204). This research is showing fundamental differences between verbal and nonverbal systems concerning their primary locations in the cerebellum, methods of processing during storage and recall, as well as relationships with cognitive functions such as perceptual closure and mental rotation. Developmental studies of children's drawings provide empirical support for this model (Bezruczko, 1995a).

Visual arts research. Historically, visual arts researchers have not shown much interest in relationships between visual arts learning and cognitive development prompting Gardner (1980) to comment "people with the strongest interest in children's drawings have rarely possessed deep knowledge of human development" (p. 14). Furthermore, contemporary visual arts research continues to separate the study of artistic ability from general issues of human development. Arts researchers have proposed sequential stages to describe the growth of aesthetic sensitivity (Parsons, 1987), investigated the methods and strategies that children implement to execute drawings (Freeman & Cox, 1985; Goodnow, 1977) and sculptures (Golomb, 1974; Golomb & Cornelius, 1977), and examined the changing sensitivity of children to aesthetic criteria during development (Gardner, 1973/1994) without seriously raising questions concerning their implications for (a) language and literacy development, (b) underlying relations with cognitive functions, or (c) implications for personality development.

Research Plan

In this research, two studies were conducted to examine the implications of visual arts background for cognitive function and school learning. First, Study One tested the hypothesis that early visual arts learning is related to visual-spatial and fine motor development by comparing clay models constructed by kindergarten and Third grade children attending four schools differing dramatically in their emphasis on visual arts learning. Features of their models were analyzed, first, for objective differences between art- and non-art-trained children, and, second, for empirical relationships with nationally normed reading and math test scores. The results of this study of clay models were then extended in Study Two by examining a six-year longitudinal record of test scores for a cohort in these schools.

This approach to investigating children's art, e.g., visually examining distinct qualities and assigning numerical values, adapts historical methods researchers developed studying children's human figure drawings where features such as detail, clarity, and overall size, rated by judges, were statistically correlated with test IQ. Its application here, however, is not intended to find relationships with an underlying IQ manifold, but, rather, to determine (a) if these features have an independent status from each other, (b) whether children from different visual arts backgrounds manifest these features in their clay models differently, and (c) whether any of these features have statistical relationships to school learning. Admittedly, this method is not popular among empirical researchers because it requires painstaking concentration by trained observers to frequently subtle, qualitative details in children's art. Consequently, its application is usually wrought with error making interrater reliability and construct validity central issues throughout the procedure. An advantage of this method, however, is its emphasis on features in children's art offering the greatest contribution to theoretical advances thus increasing a study's efficiency and validity. Moreover, meeting the empirical requirements for this method can provide astonishing insights into children's development that are simply not possible with more globally-oriented methods. A tradeoff in this analytical approach to features in clay models is that everything else, perhaps just as interesting and valuable as the features isolated, are eliminated from the analysis. Consequently, this approach requires caution concerning its scope. An investigation too narrow in scope may lead to trivial results, while one that is too broad ultimately becomes unmanageable and its results uninterpretable.

In this research, several features of clay models were selected to represent important aspects of cognitive function. Differences in overall shape and position of a model along a vertical plane were selected to represent differences among children in spatial abilities, while Exhibition, the rated attractiveness of a model as judged by adult raters, was expected to represent sensitivity to, if not emergence of, adult aesthetic standards. Several features such as Fidelity, Clarity, Detailing, and Integration were adaptations of Goodenough's scoring system for human figure drawings, and these features were expected to show relationships with school learning.

Other visual arts researchers have implemented this approach to children's art (see Csikszentmihalyi & Robinson, 1990; Machotka, 1966). Machotka (1966), for example, focused on criteria underlying children's visual preferences and found a shift in their evaluation of clarity, style, composition, and color. Csikszentmihalyi and Robinson (1990) proposed perceptual, emotional, intellectual, and communication features as major dimensions of aesthetic experience. Golomb (1993) applied this method to clay models emphasizing posture and other features related to three-dimensional representation. In visual arts achievement testing, this approach helped define instructional domains within a visual arts curriculum (Bezruczko, 1989, 1995b), while Brown (1992) conducted international comparisons of drawing performance with a rating scale based on several discrete aspects: shape, detail, depth, balance, dominance, symmetry, transparency, and proportion.

In summary, this research addresses the following questions:

1. Do young children who participate in an organized program of visual arts learning show evidence they are developing unique art-related spatial abilities? If so, what implications do these spatial abilities have for their art making?

2. Do visual-spatial, as well as artistic, aspects of children's visual art show statistical relations to school learning?

3. Do children attending elementary schools that emphasize the visual arts attain higher levels of school achievement than children of comparable socioeconomic

background and school ability who do not?

METHOD

Study One

Sample. This sample is 201 children, slightly more boys than girls, in intact kindergartens and third grade classrooms in four Chicago public elementary schools differing in their emphasis on the visual arts. Two of the schools were chosen because they provide visual arts education (one of which provides a comprehensive schoolwide multi-arts program), and they were socioeconomicly matched with schools that do not provide children visual arts training. (Henceforth, children who attended a school with visual arts education are referred to as art-trained children; those who did not as non-art-trained children.)

Racially, one of the schools with an arts program is predominantly African American with other minorities. Economically, many of these children are from poor families with 30 to 40 percent of the children receiving Federally subsidized school lunches. Because this school and the one matched with it are both magnet schools [5], children are bused to them each day from around the city. The other school with an arts program is predominantly white with almost no poverty. This school and its nonart match are located in neighborhoods, hence the children are not bused. Table 1 presents key sociodemographic features for the schools and their neighborhoods (Chicago Public Schools, 1989).

Table 1 about here

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Visual arts education. Although the two elementary schools in this study with visual arts education employ full-time certified art teachers, and children begin the programs upon their enrollment in kindergarten, their arts programs differ substantially. One of these schools, hereafter referred to as Art_1, provides children an intensive arts curriculum involving not only visual art, but music, drama, and dance in an overall creative and expressive school environment. This school employs a complete staff of certified art teachers (music, dance, drama, as well as visual arts) in addition to primary school classroom teachers, and the school puts prominent emphasis on arts achievement, as well as traditional basic skills learning. Well-known for this joint emphasis on arts and academic learning, the school attracts disadvantaged minority children from around the city.

The second elementary school with art, hereafter referred to as Art_2, has an arts program that is more modest than Art_1 both in its resources and emphasis. Although the school employs a certified art teacher, and children are provided visual arts education in a variety of media throughout their elementary schooling, the arts program in this school only provides enrichment and diversion.

The two elementary schools without art ($Nonart_1$ and $Nonart_2$) do not employ art teachers, thus visual arts in these schools, if at all, is provided at the discretion and convenience of their classroom teachers. Consequently, arts education for these children varies from year to year depending on available resources and their teachers' personal interest. $Nonart_1$ is noted for its academic program and, like Art_1, draws children from around the city.

Art_2 and $Nonart_2$ schools are especially interesting because both have substantial school resources, are not located in economically disadvantaged neighborhoods, and are attended predominantly by white, working-class children, yet they have made explicit decisions to put only secondary or no emphasis, respectively, on arts education.

Clay models and test scores. Using standard instructions, a clay model was collected from children at the end of the school year. The models were permanently recorded on high-quality 35 mm photographic transparency film that was commercially developed [6]. Three trained judges examined high-resolution projections of the photo-transparencies [7] and assigned ratings, 0 (*low*) to 3 (*high*), to physical and nonphysical features such as height, shape, clarity, texture, and detailing. These features, among others, were selected because their presumed relationships to cognitive function have important implications for advancing developmental theory. (An appendix summarizes the 13 features analyzed in this research.)

Annually, the Chicago Public Schools administer the *Iowa Tests of Basic Skills* (ITBS), nationally normed multiple choice tests of reading and math achievement, to assess school learning. (The ITBS is widely considered to test achievement on a conventional American school curriculum. Test reliability for the ITBS is generally high, alpha > .90.)

Procedures. With groups of 20-25 children, the author conducted a clay modeling activity. Each group was shown a 22- by 25- inch full color poster of a large dog sitting on his haunches. (This subject was selected because of its general appeal and familiarity to children of all ages.) After discussing for several minutes the features that distinguish a dog from other animals, children engaged in the following mental imagery exercise to prepare them for the activity. Following directions, all children closed their eyes and imagined a dog. With their eyes closed, they were instructed to trace the shape of a dog with their hands in the space in front of them and to think about the features of a dog. The imagery exercise lasted 45 seconds. (During the exercise, the author provided the children with an oral narrative describing special canine features and highlights, e.g., their furriness, the tail and the ears, differences from a cat or a bird, and so on.) When the children opened their eyes, each was provided with two pounds of modeling clay and instructed to make a clay model of a dog. (The poster remained on display throughout the activity, and the children were encouraged to look at, as well as think about "how a dog looks".)

The length of the activity differed according to children's age. The youngest children spent approximately 20 minutes while the third grade children considerably more, sometimes an hour, but none of the children were prevented from completing their models because of time. All of the clay models were completed in a single session.

Analyses. After transforming the ratings to standard scale values [8], several analyses were conducted to establish group differences. First, overall differences between the art and nonart groups were examined with a 2 (grades) X 2 (visual arts background) analysis of variance to identify differences in features attributable to visual arts education. (Different grade levels represent differences in ages.) Then within the groups, the features were correlated with test scores to reveal the specific features related to school learning. (The results from this separate analysis should replicate and clarify the group differences found in the overall analysis.)

Study Two

After analyzing the clay models in Study One, a second study considered the practical implications of early visual arts experience for elementary school learning by examining six years of test scores for these four schools.

Figure 1 about here

Figure 2 about here

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Sample. Using archived computer records in the school system's central offices, six years of standardized achievement test scores were identified for a cohort of 414 children from these schools (approximately equal representation of boys and girls). In order to simplify their comparison only children who enrolled in the schools at the beginning of Grade one and remained with their class through Grade six were included in the analysis. Consequently, the confounding influences of grade retention, family mobility, and special education placement were eliminated from this sample.

RESULTS

Study One

Figures 1 and 2 present typical clay models by art- and non-art-trained children in kindergarten and Grade three. They show the kindergarten children without visual arts training producing less mature-looking clay models than their art-trained counterparts (e.g., kindergartners without art education produced clay models with missing parts and less detail). Oftentimes, their clay models lay flat on the table, suggesting an inability to construct an upright three-dimensional figure. (Even when provided with adult encouragement and assistance, they were still unable to construct an upright model.)

By the third grade, however, the non-art-trained children produced clay models remarkably similar to the art-trained children: Their third grade models showed considerable detail, such as facial features and extremities, as well as better-proportioned overall shapes. Despite this improvement, however, the art-trained models continued to show slightly better overall integration (the parts contributing more to a holistic image and tighter composition), as well as significantly more posing than the non-art-trained group.

Descriptive Statistics

The overall means and standard deviations in Table 2 show Texture (surface structure) received the highest ratings for the combined art and nonart groups indicating that most children systematically manipulated the surface texture in their models. The second highest rating concerned the ability to integrate individual parts into a whole. Almost all the models (Art and Nonart) by the third grade had the main parts for a dog; that is, head, tail, legs, paws, and so on, as well as an identifiable placement.

Table 2 about here

The judged readiness of a model for public exhibition (Exhibition) received the lowest overall rating indicating, not surprisingly, that young children tend not to produce models that look ready for adult-juried competition. (Nonetheless, at least one child in each group was exceptionally talented producing an artistically stunning model even by adult standards.) The degree to which the models displayed affective expression (Expression) such as happiness or sadness also received exceptionally low overall ratings.

Table 3 presents intercorrelations supporting the relative uniqueness of these features. The highest correlation between two features is .68 for both (a) Shape and Clarity and (b) Technique and Detail, while the lowest is .20 between Fidelity and Height. The median intercorrelation for 13 features is .49 (.5 correlation represents only 25% common variance between two variables). Interrater reliability of the coding scheme for seven rating sessions ranged from .70 to .95.

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Table 3 about here

Although the purpose of this study was not to develop an ability scale, the overall scale reliability for 13 items is .90[9]. Arranging these features on a continuum according to their relative frequency provides some insights into the progression of skills underlying sculpting ability. At the far left end of this continuum are the most-frequently observed features relating to shape, form, and the basic integration of parts into a whole. These features depend on gross motor operations and should be relatively easy for these children. All of the children attained some degree of proficiency with these features. More difficult to show in these models were features relating to physical refinements such as putting models in an upright position, and success at converging on a coherent representation for a dog. These features, not surprisingly, require more fine motor skill and developmental maturation than the easier shape-related features. Consequently, they fall toward the middle of this continuum. Finally, at the far right of this continuum are features involving expressive and aesthetic qualities. Very few children reached this level of development suggesting it is the most difficult for them to achieve.

Group Comparisons

In general, the group comparisons in Table 4 present compelling evidence that visual arts education contributes significantly to differences in children's art products that are independent of maturation. The art-trained kindergarten children received higher values than their non-art-trained counterparts on all features except Technique. In third grade, the magnitude of these differences diminish, but the art-trained children continue to show significantly higher values on all features except Height, Displacement, Texture, and Expression.

Table 4 about here

The results of an age by training analysis of variance in Table 5 provide insight into the separate influences of developmental maturation and visual arts learning. An age effect indicates that between Kindergarten and Grade Three the models differed significantly on all features except Displacement. This difference is important because it identifies an influence of maturation that is independent of visual arts education. A training effect, which represents differences in the models due to art education, shows the models still differ significantly on Fidelity, Position, Clarity, Displacement, Pose, Integration, and Exhibition. An astonishing finding given the crudeness of the observation model.

In summary, these results show the models significantly changed over time for all children, but they changed even more on several characteristics (Fidelity, Position, Clarity, Displacement, Pose, Integration, and Exhibition) for children with a visual arts education background.

Table 5 about here

Table 5 also shows significant age by training interactions for Displacement and Technique, respectively. The art-trained children used significantly less clay in their models between kindergarten and Grade 3, hence their lower Displacement values, while the non-art group used significantly more clay. Technique is interesting because the groups did not differ statistically, but the art-trained children showed a significantly greater within group increase from Grade 1 to Grade 3 than the nonart children. (The smaller models by the art-trained children also tended to show more details in Grade 3.) A surprise in these results is that Height, Shape, Texture, and Expression, in addition to Technique, failed to differ between the groups.

Figure 3 shows the 13 features tended to appear in the models less frequently for the non-art-trained group than the art-trained group. (In this analysis, less frequently observed features are interpreted to be more difficult.) Ratings for the non-art-trained group also show a wider range than for the art-trained group. (This difference probably reflects the somewhat more homogenous visual arts background of the art-trained group.) Figure 4 shows that adding the 13 features together, the art- and non-art-trained groups by Grades 1 and 3 differed .38 standard deviation units[10] in sculpting ability. Figure 4 shows this difference is maintained through Grade three.

Figure 3 about here

Figure 4 about here

Correlations Between Features and Test Scores in Third Grade

Figure 5 presents correlations between the features and school learning for third grade art and nonart groups. These results are important because they show Shape, Clarity, and Technique to correlate significantly with school learning for both the art-trained and non-art-trained children suggesting that these relationships are part of the course of normal cognitive development. Then an examination of only the art-trained group shows important additional correlations between school learning and the following features: Fidelity, Position, Integration, Exhibition, Detail, and Height. These additional relationships represent linkages due to visual arts background.

The qualitative implications of this research are straight forward. By Grade 3, children who produced well formed and more true-to-life models (more clearly defined dog shapes in an upright position projecting a pose with both physical and expressive details), as well as artistically attractive, tended to receive significantly higher standardized school achievement scores. The clay models of non-art-trained children, on the other hand, only show correlations of achievement scores with Shape, Clarity, and Technique. Consequently, these results suggest that early visual arts experience contributes to children's cognitive function and are probably linked to their school learning by several spatial abilities, fine motor development, and an aesthetic attitude.

Figure 5 about here

A final series of analyses was conducted by regressing standardized math scores for the overall third graders on the model features. These results reveal that Position and Pose (both depend on coordinate spatial abilities), as well as Exhibition ratings (an artistic ability) to be associated with 15 percent of the overall third grade math scores ($F = 2.38$, $df = 41$, $p < .10$, R^2 .15; unadjusted for shrinkage) and a comparable amount for reading. (Adding more features to the analysis increases the level of significance but does not increase the portion of variance explained. Consequently, only the parsimonious model is presented here.)

Study Two

Longitudinal analyses of school learning and visual arts background. Figure 6 presents math scores for a longitudinal cohort in these schools. It shows differences among the schools at the end of Grade 1 to be statistically insignificant, but by the end of Grade 3 the art-intensive elementary school, Art_1, showing significantly higher math achievement scores than the other schools ($F = 3.11$; $df = 387$; $p < .05$). In fact, an analysis of covariance of the math scores (controlling for family income and race) in Year six shows this school to score .63 standard deviation units above the overall Grade 6 mean ($F = 10.50$; $df = 414$; $p < .001$) [11].

Figure 6 about here

DISCUSSION

Research was conducted to identify prominent features in children's clay models and their relationships with school learning for young children who underwent dramatically different visual arts programs in four urban elementary schools. One of the schools did not provide visual arts education, and at the other extreme, one provided an extensive multi-arts experience. None of the schools emphasized sculpting or three-dimensional modeling projects. An examination of clay models collected from these children, indeed, revealed significant relationships between specific features in children's clay models and standardized measures of school learning. A longitudinal analysis then established long-term schooling effects.

Overall, clay models by art- and non-art-trained children differ in their (a) accuracy and clarity, (b) physical orientation in space, (c) integration of parts into a whole, as well as (d) artistic values. Somewhat surprisingly, the groups did not differ in their shaping of clay into a concrete image (or at least the observation method was not sensitive to these differences) or their implementation of a formal technique. Nor did the groups differ significantly in their expressiveness. (The models tended to show smiles or nothing at all.)

These results reflect both maturational and educational influences. The similarities found between art and nonart groups in shaping and expressing an image in clay, and their lack of difference in technique, probably indicate basic developmental processes underlying the growth of all children. Visual arts programs intending to enhance these aspects of children's sculpting ability probably require more intensive learning experiences than are commonly found in urban elementary schools. Conversely, the significant differences between the groups after accounting for maturation suggests important school effects for visual arts education.

Links Between Arts Background and School Learning

Some of the most important results from this research concern a pattern of correlations between features in clay models and elementary school learning. The Grade 3 art-trained children tended to produce models that were true-to-life (more clearly defined shapes in an upright position projecting a pose with both physical and expressive details), as well as artistically attractive by conventional adult standards. These children also tended to receive significantly higher standardized school achievement scores. The non-art-trained children, on the other hand, had far fewer relationships between their models and school learning showing only Shape, Clarity, and Technique to correlate significantly with standardized test scores. These results need to be replicated in future research not only to establish their generality, but to gain a better understanding of the underlying mechanisms that mediate them.

Longitudinal Analysis

A longitudinal analysis revealed an interesting pattern of standardized math scores among the schools (reading shows a similar pattern). While the schools did not differ significantly at the end of Grade 1, differences among them steadily increased through Grade 6[10] with the art-intensive school attaining the highest level of performance on standardized achievement tests. These results, however, are shocking, because they also reveal that children in schools putting only secondary emphasis on visual arts learning, in fact, performed less-well on standardized tests than students without any art at all! (Art_2 actually scored lower than $Nonart_2$ or $Nonart_3$ in Grade 6.)

A plausible explanation for these results concerns a common feature of all these schools: An over-bearing emphasis on traditional academic school learning. Teachers, as well as students, are evaluated solely by students' performances on standardized reading and math tests. (Teacher promotion, student advancement, and school ranking are based on these results.) Moreover, learning in these schools is oftentimes haphazard and inefficient, and teaching methods frequently rely on archaic rote learning methods such as monotonous drill and practice. Consequently, schools that try to maintain an arts program that parallels the traditional school curriculum may be simply reducing children's exposure to already ineffective school instruction. This issue is exacerbated by school climate. In general, these schools tend to be physically harsh and psychologically intimidating reflecting a social milieu in the surrounding neighborhoods of high crime and unemployment, and general socioeconomic depression. (This "toughness" tends to appear even in schools in less disadvantaged areas of the city.) Under these conditions, visual art experiences with the exception of Art_1, the arts-intensive school, tends to be isolated and removed from the cultural mainstream, perhaps even out of touch with the brutal realities of these children. On the other hand, Art_1 presented an extraordinary alternative to this scenario. Although its building is old and dilapidated, and the children are herded about in regimented groups, it seems much less restrictive and perhaps more spontaneous than the other schools, and the teachers somewhat less authoritarian. The overbearing emphasis on academic performance seems to be moderated here by teachers who seemed more sensitive to children's emotional needs, and, in general, this school encourages creative expression. The fact that this school consistently shows high achievement scores offers the possibility that multi-arts and basic skills learning environments synergistically interact in poor, urban schools influencing children's attitudes toward school and learning, as well as the overall school climate.

Public Policy Implications

Two aspects of this research that raise public policy issues concern a) differences in socioeconomic status of these schools and b) an apparent delay between the onset of visual arts training and its significant relationships with school learning. Although both schools with visual arts education were socioeconomically matched with comparable nonart schools, the art schools differed substantially from each other. The more-intensive art school was primarily attended by economically disadvantaged, urban children from violent, crime-ridden neighborhoods, while the less-intensive art school was predominantly white with almost no poverty in a suburban-type neighborhood. The more-disadvantaged school, however, showed the highest school achievement [12]. This difference in socioeconomic background and school learning raises questions, first, concerning the types of visual arts programs that offer a potential benefit to school learning, and, second, the possibility that socioeconomic background interacts with type of visual arts program. Other longitudinal studies of disadvantaged children in preschool and kindergarten are showing significant relationships between early childhood curricula that explicitly include drawing and children's attitudes toward school and the motivation to learn during elementary school (Bezruczko, 1995a). (Children who draw at a young age like school more and earn higher grades all the way through elementary school.) Speculation suggests that early art experiences offer poor urban children a type of excitement and satisfaction that may be lacking in their homes and neighborhoods. Some evidence suggests these children benefit more from comprehensive and organized early art programs than less-disadvantaged children who are already receiving substantial visual arts stimulation in their homes and communities. Snow (1983), for example, describes the extensive literacy preparation of children by mothers in middle-class families. She found these mothers preparing children for school by telling stories and asking questions thus building shared "histories". These interactions, frequently lacking in poor, urban families, build internal representations of life events that promote children's transition to formal schooling. Including visual art with verbal interaction in early childhood programs for economically disadvantaged children would probably alleviate somewhat this initial discrepancy in early language experience.

Another implication of this study, discussed above, is that several years of continuous and intensive early visual arts experience may be necessary before standardized test scores begin to reflect cognitive differences in mental development attributable to visual arts learning. While this study shows that children's clay models differ significantly at the end of kindergarten, these differences probably only reflect low-level fine-motor, perceptual and spatial abilities that are not immediately related to performance on standardized tests, such as the ITBS, early in children's schooling. The results here suggest the cognitive benefits for several years of intensive arts early education may not appear on standardized achievement tests until mid-childhood.

Limitations

An important limitation in all field research concerns the issue of self-selection. Children were not randomly assigned to these schools, consequently, parents had the opportunity to exercise personal preference when enrolling their children in kindergarten for magnet elementary schools Art_1 and $Nonart_1$. (Art_2 and $Nonart_2$ are neighborhood schools where issues of self-selection are less relevant.) Consequently, families who chose Art_1 may differ substantially from families who chose $Nonart_1$, a comparable school without art. One can further speculate that Art_1 families who emphasize visual arts training for their children, inspite of their financial problems (40% were low income), may differ in other values such as their participation in the school program (communicating with teachers, attending school functions, and so on), community, and political events, as well as their value on travel, music, and other sociocultural activities. Their family expectations for children's school success may differ as well. Although socioeconomic background was carefully matched in these studies, parents' attitudes were not. Consequently, the amount of influence that parents' attitudes have on the structure of relations between visual arts background and school learning needs to be determined.

This study is also limited by its concentration on generally physical features of children's clay models such as texture, size, volume, detailing, and so on. These features are relatively convenient for an empirical study, but they fail to address some of the most interesting questions concerning early art and development. The growth of logical reasoning, semantic content of the images, and the child's manipulation of symbols and their interrelations with language could not be addressed at this time. Consequently, this research represents only an introduction to insights about development that children's art can provide.

Future Studies

Future studies of visual art background and children's cognitive development are needed to (a) establish the influence of parents attitudes towards art, (b) clarify the effectiveness of alternative art education models for supporting school learning, and (c) explore the underlying mechanisms that link early symbolization and art with cognitive development.

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Appendix

The clay models were rated 0 (*low*) to 3 (*high*) on the following features:

1. *Fidelity*. During the activity, children were presented a large color photograph of an Irish Setter, a playful dog not generally considered threatening or aggressive to children. Fidelity represents the child's accuracy producing a three-dimensional model of a dog from this two-dimensional photograph. This rating, indicates, "How much does the model look like a dog?".

2. *Height*. Represents the vertical physical measurement of the model from the base to top.

3. *Position*. Children differed in the way they set their models up. Many children set their dogs up on legs, while others did not. Golomb (1972) referred to this characteristic as "vertical uprightness". The models up on legs tended to look more mature and developed. This rating indicates how well children established a means of support for their models.

4. *Shape*. The overall physical operation of this activity is to shape the clay into a form that resembles an animate object. Consequently, children were rated on the amount of shaping (head, torso, tail, and so on) reflected in the final form of their model. A low scoring model tended to look like an undifferentiated mass. A higher scoring model tended to have at least the outline of a dog.

5. *Clarity*. Although all children received the same directions, they were encouraged to think about how a dog looks to them and not simply to copy the photograph. Consequently, children differed tremendously in the goal they established for themselves. Some children tried to produce very elaborate models with considerable detail, while other children were less ambitious. Clarity represents how successful a child was in reaching closure on his or her particular plan.

6. *Displacement*. Cubic area of the clay model estimated from the length and width of the base and the height.

7. *Texture*. All the children rendered the surface of their models in some manner. The surface for some models was choppy and uneven suggesting the child was unfamiliar with the medium. Other children produced extremely smooth and uniform surfaces that they shaped into elegant contours.

8. *Pose*. Unlike Position which represents simple upright support, Pose represents the child's attempt to explicitly pose the model. To varying degrees, children arranged the head, paws, tail, and so on to affect a particular pose.

9. *Integration*. Each model was rated for consistency between parts and whole.

10. *Technique*. Children differed in the strategies they implemented to produce a model. Some showed deliberate planning and methodical execution, while other children relied on ad hoc procedures.

11. *Detailing*. The models differed in their detail Some children only produced the general shape of a dog with little elaboration, while others worked laboriously to show intricate detail in the tail and paws, as well as the eyes and ears. Some children were even successful creating the illusion of fur.

12. *Expression*. Most children produced models with happy facial expressions.

13. *Exhibition*. Some children showed an extremely high level of artistic sophistication and talent in their models. Their models were highly stylized, beautifully proportioned, and very attractive. These models would have received favorable attention in a public exhibition.

Author Notes

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Endnotes

1. Nikolaus Bezruczko, Ph.D. is chairperson of the *Chicago Objective Measurement Table* affiliated with the MESA Psychometric Laboratory at the University of Chicago.

2. In studies of drawings by disadvantaged children, Eisner (1969) found reading and drawing scores to correlate .40 (see also Hess-Behrens, 1973). Other research has shown Goodenough Draw-a-Man Test scores to correlate positively with intelligence ($r > .50$) and cognitive aptitude tests (Ansbacher, 1952; Harris, 1963). Other research shows relationships between drawing ability and tests of reasoning, spatial aptitude, and perceptual accuracy (see Anastasi, 1982).

These relationships between children's art and cognitive abilities are not limited to test scores and drawings (Lansing, 1984). Dennis (1966) showed that the amount of experience that children have with representational art influences their drawings, and other researchers have shown that children's physical operations during an art activity are related to the complexity of their thought structures (Greenfield & Schneider, 1977). Researchers have also reported direct relationships between art-related training and children's cognitive functions (Gair, 1975-1976; Saltz, Dixon, & Johnson, 1977; Walker, 1980).

Price-Williams and Gordon (1969) compared geographically-disparate Mexican children (matching on age, years of schooling, and socioeconomic status) who differed in pottery making skills. The children learning pottery at a young age received significantly higher substance conservation scores and conserved more frequently on four other tasks (number, liquid, weight, and volume). Studies of children's symbolizing behavior show that the types of metaphors in their play are also significantly related to their object conservation (Nicolich, 1977), and Golomb and Cornelius (1977) showed that several brief practice sessions in symbolic play facilitates the acquisition of number conservation.

Relationships between cognitive abilities and visual arts background have also been found in adults. Child (1964) found a positive relationship between artistic judgment scores and Scholastic Aptitude Test scores for college students. A battery of standardized mental ability tests including spatial ability, inductive reasoning, visual memory, pitch discrimination, and English vocabulary showed positive correlations with visual arts background (Bezruczko & Schroeder, 1990, 1991; Eysenck, 1972; Likert & Quasha, 1948; Rosenblatt & Winner, 1988; Woods, 1953; see also Child, 1964). Controlling these relationships for age, education, and education of parents did not eliminate them (Bezruczko & Schroeder, 1991). In a longitudinal study of adults, Getzels and Csikszentmihalyi (1976) found large differences in perceptual abilities between artists and nonartists; this difference was characterized by the ability to visualize three-dimensional objects in two-dimensional space. Winner also found that art and math majors outperformed psychology majors on a spatial ability task (Winner, 1988; see also Winner, Casey, Dasilva & Hayes, 1991). In another line of research, Getzels and Csikszentmihalyi (1976) emphasized the problem finding aspects of visual arts experience and cognitive development (see also Csikszentmihalyi & Getzels, 1988).

Pellegrini and Galdi (1991), however, present an alternative perspective on early visual arts experience and school learning. Their research concerning play, symbol acquisition, and language development shows that children drawing alone is not sufficient to stimulate the semiotic functions that are believed to underlie literacy development. Their research shows children must be practicing symbolic representations of objects, roles, and events in their play. Other researchers are finding that a symbol competency acquired through play also generalizes to other representational domains such as language comprehension (Fein, 1979), language production (McCune-Nicolich, 1977), and emergent reading and writing (Galda, 1984; Pellegrini, 1985a, 1985b).

3. This progression in human figure drawing typically begins with children two to three years old extending into middle childhood. Human figure drawings by very young children tend to be disorganized, undifferentiated, and difficult for adults to interpret, yet highly expressive. Over several years these drawings follow a pattern of change that is remarkably consistent (at least in

Western culture). Their early scribbling evolves into tadpole creatures of many varieties (see Golomb, 1992; Gardner, 1980), and in time, the drawings become increasingly true-to-life with considerable detail and clarity.

4. Dyson (1982) describes the undifferentiated status between drawing and writing for young children, and Brittain (1979) describes the progression from scribbling to graphic symbolism. Thus, Dyson concludes "Between the ages of three and six, children's controlled scribbling gradually develops into . . . linearity, horizontal orientation, and the arrangement of letterlike forms." (Dyson, 1982, p. 361). Other research, however, shows that children do in fact understand the differences between drawing and writing (Karmiloff-Smith, 1992) suggesting that early drawing experiences enhance children's ability to distinguish the separate rules for drawing and writing symbol systems.

5. Magnet schools are unusually well-equipped with educational facilities and resources not available in neighborhood schools. The schools are open to any child in the city, but selection is conducted by lottery because applications consistently exceed enrollment capacity.

6. The models were photographed with a hand-held Canon F-1 35mm single-lens reflex camera and a fixed length 85 mm portrait lens using 400 ASA Fugichrome color transparency film at 1/60 shutter speed. Ambient light (both overhead florescent and daylight) provided illumination. One shot showed the front and side of the model. A second photograph was taken directly from above.

7. Photographic transparencies offer several advantages over examining soft clay. Numerous observation sessions by many raters physically handling the clay would distort the models and undermine the integrity and validity of the results. (Physically storing several hundred soft clay models without damaging them for several years presents another issue altogether.) An additional benefit of the projected transparencies is the elimination of variability in repeated observations. Background lighting, extraneous shadows, angle of view, distance from the judge, and so on are held constant increasing rater reliability.

8. A problem with analyzing numerical values from likert-type rating scales is the unknown relationship between the numbers assigned to observations and the underlying quantitative properties of the measuring scale (Wright & Stone, 1979), and in particular, the magnitude and regularity of the psychophysical unit. While contemporary social scientific methods tends to ignore this issue, it represents a source of ambiguity and imprecision for an empirical analysis. To eliminate this problem, the raw ratings in this study which are on an ordinal scale with an unknown unit of measure were transformed using BIGSCALE computer software (Wright, 1989) to equal interval measures on a probabilistic scale with an explicit origin and an empirical standard error.

9. Within feature values ranged from .60 to 1.11 where clarity showed the widest range. The Pearson Product-Moment intercorrelations of the codes ranged from .20 to .68 with a mean of .47 indicating that these features represent relatively unique aspects of clay models with some overlap. The correlations of individual characteristics with the total ratings (simple sum for the 13 ratings) ranged from .05 to .76. This result suggests that increases in the ratings for most of the features is associated with higher overall ratings suggesting this particular set of features define an art-related psychometric construct.

10. Standard deviation units provide a way of comparing groups that eliminates differences due simply to random variation. Standard deviation units in this research were computed by the following expression (GroupA - GroupB/Overall standard deviation).

11. This longitudinal comparison was terminated in Grade 6 because there after children begin transferring to other schools eliminating the possibility of simple, clear longitudinal comparisons. Children in Art_1, a fine arts magnet school, was especially effected by the Grade 6 change in

enrollment.

12. Elementary school Art_1 has the highest percentage of limited-English speaking children, the highest percentage of low income students, and a relatively high representation of minority children (70%). In Grade 1, test scores for Art1 and Art2 were comparable showing insignificant differences, but by Grade 6 the poor urban children were scoring substantially above their more-affluent suburban type counterparts.

Table 1

Description of the Schools

	Percentages							
Elementary School	Low[a] income	Stability	Attendance	Limited English	White	Black	Other[b]	N[c]
Art_1	40.2	97.8	95.5	10.4	30.0	40.0	30.0	P
$Nonart_1$	35.5	97.0	94.1	7.8	27.4	30.6	43.0	A
Art_2	5.4	97.4	94.6	0.0	57.1	33.0	10.0	W
$Nonart_2$	4.6	95.1	93.6	0.0	61.0	37.0	2.0	W

Note. Elementary School Art_1 emphasizes a broad program in the arts and employs a staff of art teachers. Elementary School Art_2 provides visual arts training in their programs on a regular basis. $Nonart_1$ and $nonart_2$ do not offer art training in their school programs. Art_1 and $Nonart_1$ are matched magnet schools in which children are bused. Art_2 and $Nonart_2$ are matched neighborhood schools. Percentages may not add to 100% because of rounding (see Chicago Public Schools, 1989).

[a]Established by eligibility for federally-subsidized free lunch program.

[b]Includes Hispanic, American Indian/Alaskan, and Asian/Pacific Islander.

[c]Describes the neighborhood immediately contiguous to a school: P (urban poor and nonwhite), A (urban affluent and white), W (urban working class and non-Anglo-white).

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Table 2

Description of Features Rated in Children's Clay Models

Feature coded		mean	SD	mdn
Fidelity	Accuracy in representing a two-dimensional image in clay	.88	.91	1.00
Height	Vertical measurement of model	.94	.60	1.00
Position	Model sets on legs above the worktable	1.43	1.10	1.00
Shape	Manipulation of the clay to form a concrete image	1.56	1.00	1.00
Clarity	Model shows visual closure	1.57	1.11	1.00
Displacement	Cubic area of a clay model	1.87	.69	2.00
Texture	Uniformity in surface structure	2.02	.95	2.00
Pose	Model is posed	.79	1.07	0.00
Integration	Consistency between parts and whole	1.93	1.06	2.00
Technique	Sophistication of method used by child	1.41	.80	1.00
Detailing	Model shows fine detail in physical features	1.44	.82	1.00
Expression	Model shows affective features	.54	.90	0.00
Exhibition	Model is ready for public exhibition	.36	.80	0.00

Note. N = 201. Raters assigned values 0 (*Low*) to 3 (*High*).

Table 3

Intercode Correlations

	Height	Position	Shape	Clarity	Texture	Pose	Integration	Technic	Detail	Exhibition	Expression
Fidelity	20	54	60	67	36	54	53	50	55	48	52
Height		49	28	25	22	34	37	26	29	27	30
Position			50	50	33	56	51	41	48	44	46
Shape				68	55	48	65	63	63	44	50
Clarity					40	52	66	59	65	44	53
Texture						26	52	46	36	26	22
Pose							42	47	51	55	55
Integration								64	61	37	43
Technique									68	49	42
Detail										49	56
Exhibition											58

Note. N = 201.

Table 4

Means and Standard Deviations of the Features Coded in Clay Models

Feature coded	Kindergarten				Grade 3			
	Art		Nonart		Art		Nonart	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Fidelity	.71	.80	.43	.62	1.44	1.05	1.22	.80
Height	.89	.52	.80	.68	1.06	.47	1.11	.75
Position	1.34	1.17	.93	.85	2.02	1.00	1.41	1.05
Shape	1.19	.97	1.16	.76	2.28	.88	2.04	.90
Clarity	1.29	1.11	1.02	.79	2.20	1.06	1.89	1.05
Displacement	1.97	.70	1.61	.64	1.98	.71	2.04	.59
Texture	1.87	.97	1.79	1.08	2.26	.75	2.37	.74
Pose	.65	.98	.34	.98	1.36	1.24	1.07	1.14
Integration	1.77	1.08	1.43	.99	2.60	.76	2.19	.96
Technique	1.10	.65	1.12	.64	2.04	.83	1.63	.69
Detail	1.18	.74	1.02	.62	2.06	.74	1.85	.66
Expression	.23	.58	.16	.42	1.10	1.13	1.11	1.05
Exhibition	.21	.55	.10	.44	.84	1.08	.44	.97
Total ratings	14.39	6.77	11.90	5.24	23.26	7.62	20.37	7.89
N	62		61		51		27	

Note. Values are untransformed ratings that range from 0 to 3. Interrater reliabilities for three raters ranged from .75 to .95. Total ratings are based on a linear combination of the 13 features coded in each model.

Error	169.11	196	.86

Table 5 *Sum of Squares*

Feature coded	Sum of Squares	DF	Mean Square	*F*	*p*
Fidelity					
Age	26.57	1	26.47	39.26	<.001
Training	3.25	1	3.25	4.81	<.05
AXT	.48	1	.48	.07	NS
Error	132.68	196	.68		
Height					
Age	2.40	1	2.40	6.78	.01
Training	.06	1	.06	.17	NS
AXT	.20	1	.20	.58	NS
Error	69.34	196	.35		
Position					
Age	16.55	1	16.55	15.81	<.001
Training	11.12	1	11.12	10.63	.001
AXT	.49	1	.49	.46	NS
Error	205.12	196	1.05		
Shape					
Age	46.43	1	46.43	60.24	<.001
Training	.55	1	.55	.72	NS
AXT	.51	1	.51	.66	NS
Error	151.08	196	.77		
Clarity					
Age	38.13	1	38.13	38.33	<.001
Training	4.19	1	4.19	4.21	<.05
AXT	.04	1	.04	.04	NS
Error	195.00	196	1.00		
Displacement					
Age	1.52	1	1.52	3.37	NS
Training	2.12	1	2.12	4.69	<.05
AXT	1.95	1	1.95	4.33	<.05
Error	88.44	196	.45		
Texture					
Age	10.14	1	10.14	11.75	.001
Training	.01	1	.01	.01	NS
AXT	.42	1	.42	.49	NS

Table 5 (continued)

Sum of Squares

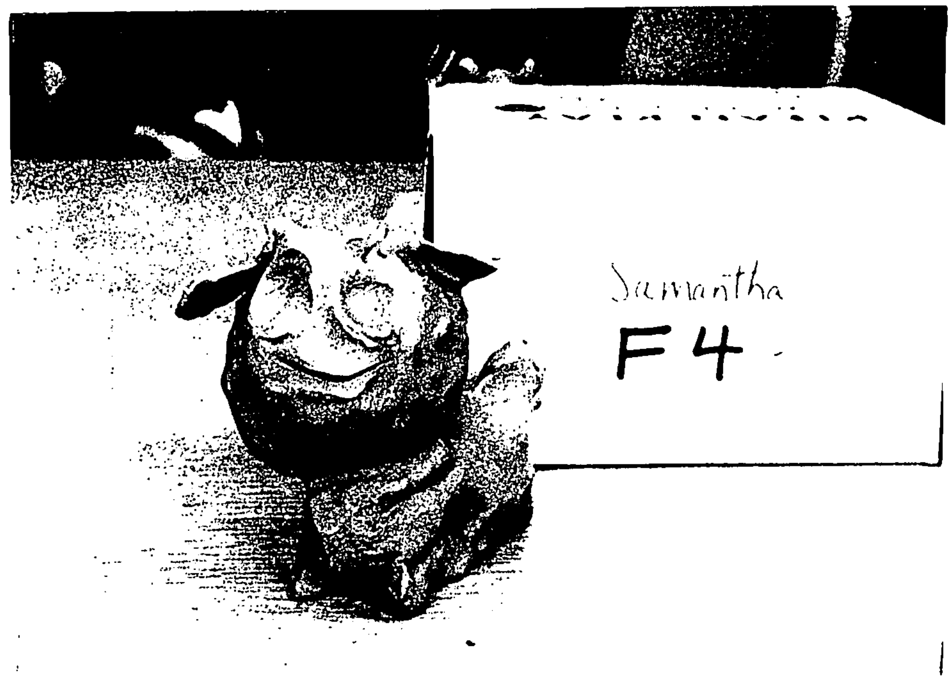
Feature coded	Sum of Squares	DF	Mean Square	*F*	*p*
Pose					
Age	24.11	1	24.11	23.95	<.001
Training	4.22	1	4.22	4.19	<.05
AXT	.00	1	.00	.00	NS
Error	197.34	196	1.01		
Integration					
Age	29.61	1	29.61	31.91	<.001
Training	6.70	1	6.70	7.21	<.01
AXT	.05	1	.05	.05	NS
Error	181.83	196	.93		
Technique					
Age	27.54	1	27.54	56.32	<.001
Training	.91	1	.91	1.87	NS
AXT	2.05	1	2.05	4.19	<.05
Error	95.83	196	.49		
Detail					
Age	34.60	1	34.60	71.94	<.001
Training	1.53	1	1.53	3.19	.08[t]
AXT	.03	1	.03	.05	.NS
Error	94.26	196	.48		
Exhibition					
Age	12.34	1	12.34	21.77	<.001
Training	2.22	1	2.22	3.92	<.05
AXT	.90	1	.90	1.59	NS
Error	111.07	196	.57		
Expression					
Age	37.88	1	37.88	60.68	<.001
Training	.06	1	.06	.10	NS
AXT	.06	1	.06	.10	NS
Error	122.37	196	.62		

Note. N = 199. Ratings were transformed to one-parameter logistic scale values and analyzed with a 2 X 2 analysis of variance.

[t]Indicates a trend

Figure 1: *Representative Clay Models by Children in Kindergarten*

Non-art-trained



Art-trained

Note that the model by an art-trained child is upright in a pose, shows more details such as ears and face, and generally shows better integration of its parts into a whole.

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Figure 2: *Representative Clay Models by Children in Third Grade*

Non-art-trained

Art-trained

Note the differences in clarity, pose, and integration of parts into a whole between the models.

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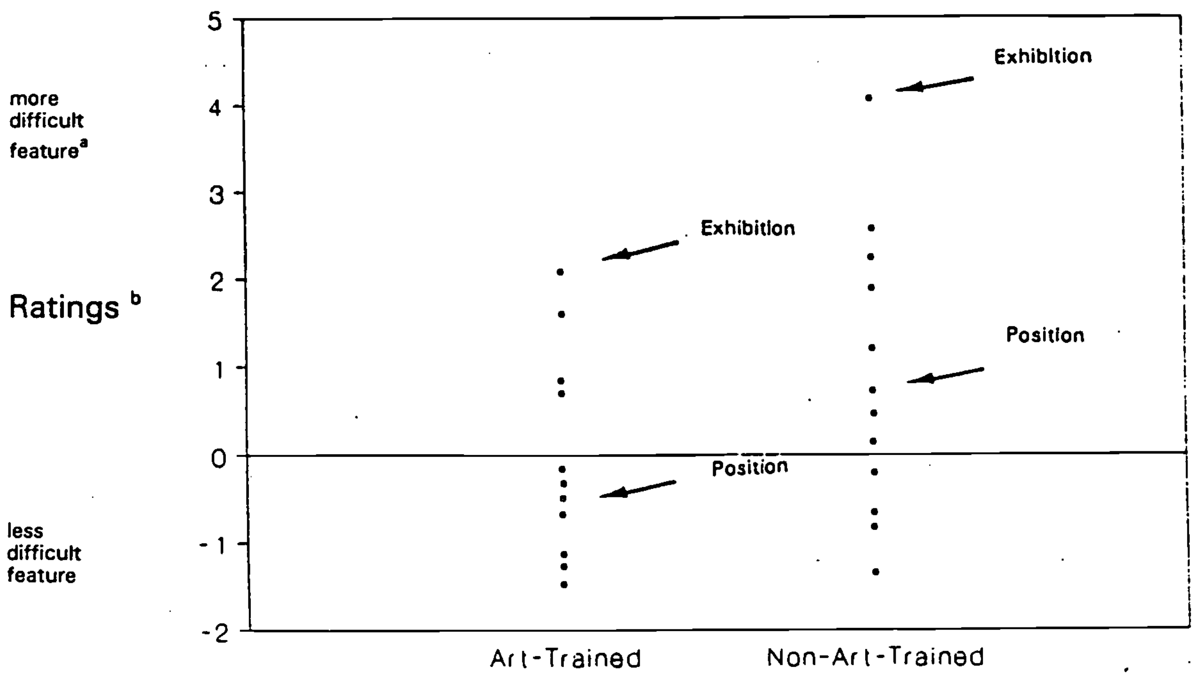
Figure 3

Clay Models Differ in Variability and Difficulty



Note. N = 201. Ratings for 13 features were transformed to equal interval scale units (logits) using the one-parameter Rasch measurement model (Wright, 1989). Zero represents the mean of the art-trained group.

[a] More difficult features on this scale indicate they were observed in fewer models.

[b] These values for the features are based on separate groups and transformed to equal interval scale units.

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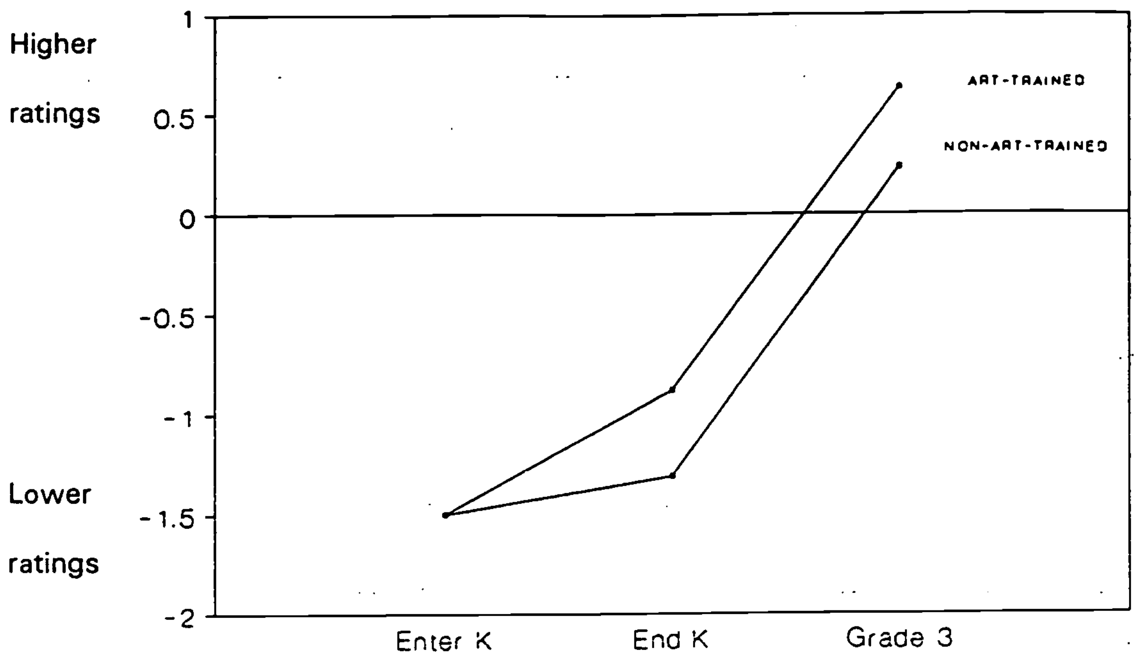
Figure 4

Total Ratings[a] by Grade



Note. N = 201.

[a]Total ratings are the sum of the ratings for 13 features transformed to equal interval scale units. In this process of estimating scale units, the mean for the art-trained group is defined as zero for the overall analysis. End K are ratings collected at the end of kindergarten, and Grade 3 are ratings collected at the end of third grade.

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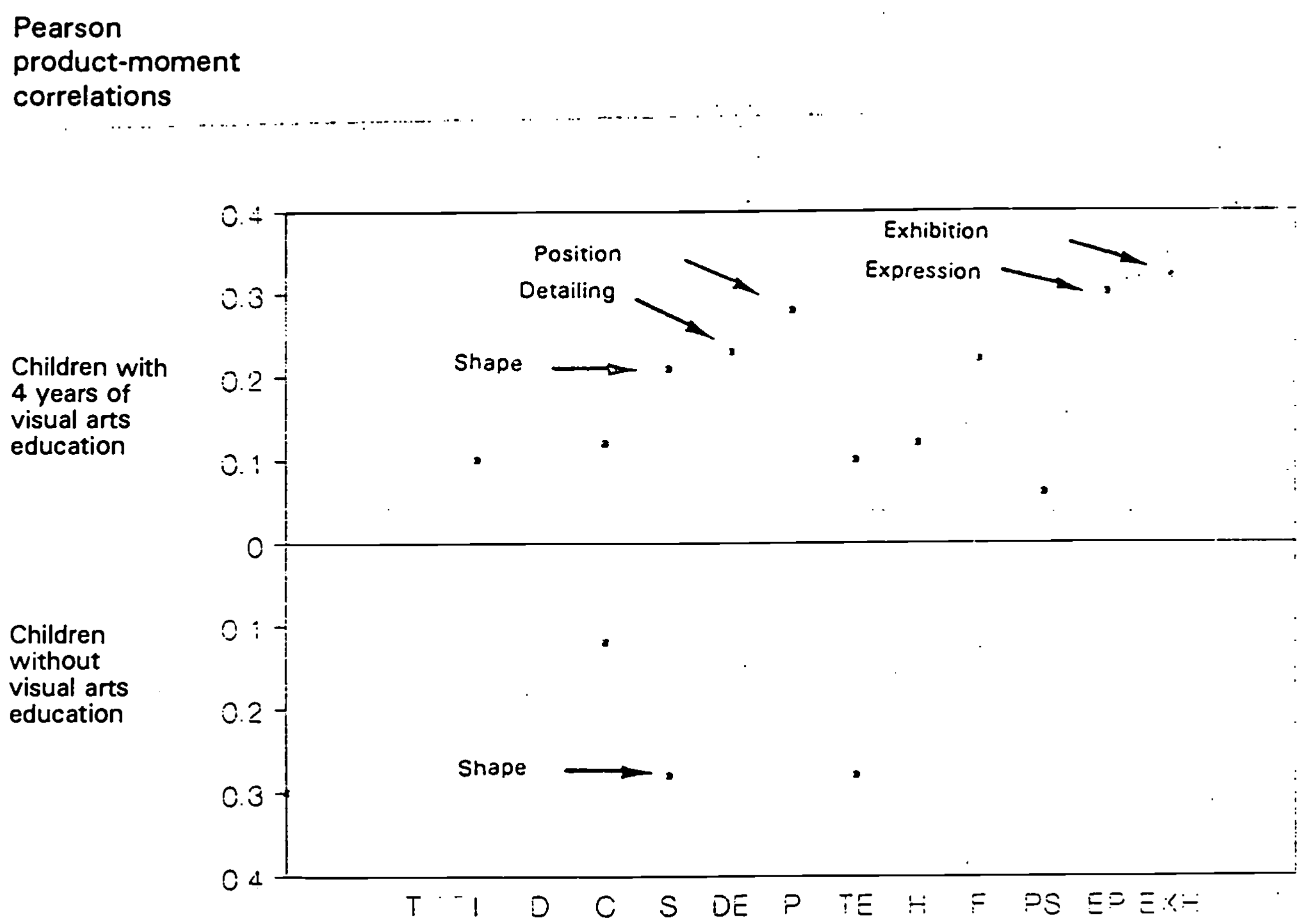
Figure 5

Positive Correlations Between Clay Models and Standardized Math Scores for Third Grade Children [a]



Note. $N = 45$. Correlations are only based on third grade models. Features on the X-axis are ordered from highest average rating (appearing most frequently in the models) to the lowest rating (rarely observed. Abbreviation of features: T (texture) I (integration) D (displacement) C (clarity) S (shape) DE (detailing) P (position) TE (technique) H (height) F (fidelity) PS (pose) EP (expression) EXH (exhibition).

[a]All relationships are Pearson product-moment correlations between ITBS grade equivalences and ratings of features significant at the $P < .05$ level.

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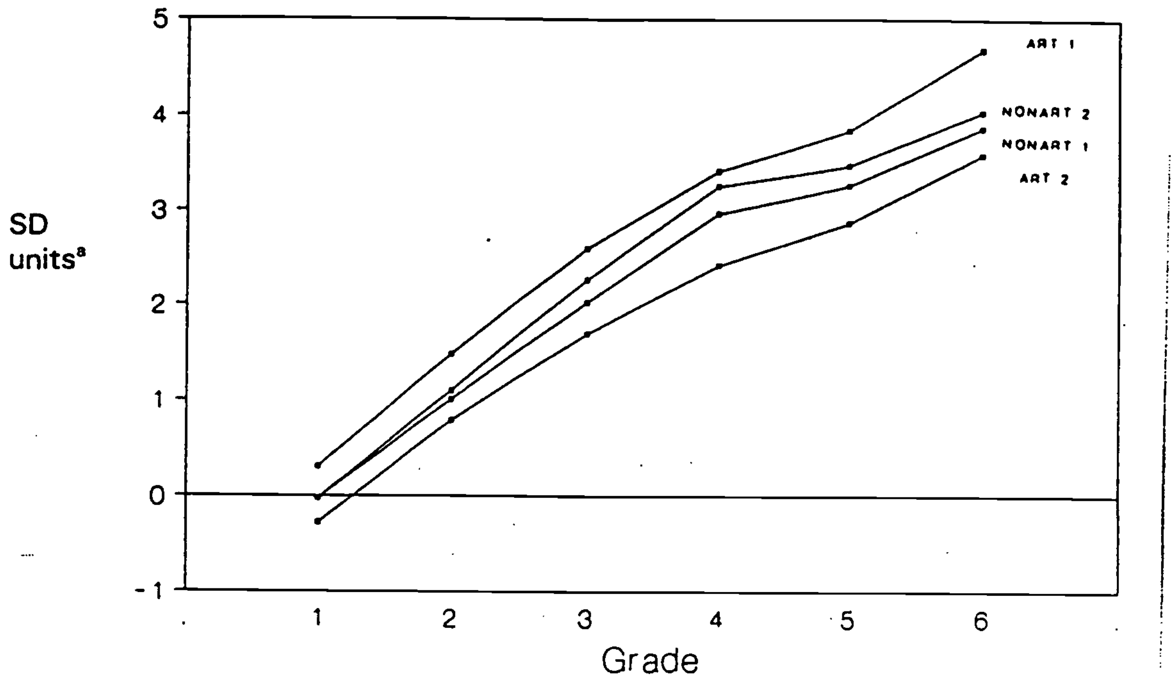
Figure 6

Longitudinal Math Scores for Four Schools



Note. *N*s range from 24 to 414. Only children who were enrolled in a school at the end of grade one and remained in that school through grade six are included in the analysis. The origin (0) was set at the overall mean for Grade 1, and the respective grade means were scaled by the overall Grade 1 standard deviation. Grade 2 through 6 were scaled by their respective overall within group mean.

[a]ITBS grade equivalences were transformed to standard deviation units.

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