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ABSTRACT

This paper examines art, a discipline that bears striking parallels, and differences, in the way it is practiced and valued in the United States and Japan. In Japan, art is a valued part of the elementary curriculum warranting as much time as science and social studies. In the United States, art is generally thought of as something extra to do if there is time left over from more traditionally academic subjects. In Japan, art is taught systematically through a series of graded textbooks, In the United States, giving the children time and materials is often the method practiced with great variation among classrooms. In this study middle class Japanese and U.S. children of ages 6, 8, or 10 years were given paper and colored pencils and asked to draw a picture of "a mother and father holding hands in a park. Their baby is in front of them and two trees are behind them." Each drawing was scored to correspond to one of four levels: (1) preaxial, (2) uniaxial, (3) biaxial, and (4) integrated biaxial. Despite almost identical compositional scores, there were noticeable differences in appearance between the drawings from the two countries. At 6 years of age, Japanese children drew scenes with more objects than requested. Very few of the U.S. 6-year-olds' drawings showed the same diversity of objects and attention to detail. At age 8, Japanese children attempted to depict objects in three dimensions more often than U.S. children. At 10, Japanese children drew more expressive figures. The findings of the study suggest that conceptual understanding is different from achievement. (DK)

Development of Spatial Understanding
in Japanese and American Children's Drawings

Development of Spatial Understanding in Japanese and American Children's Drawings[1]

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Comparisons involving Japanese and the US educational systems have become more common in the last decade. The increased interest in comparisons between the two systems can be traced partly to the cross-national achievement tests of the early eighties. Those comparisons showed Japanese children scoring at the top and American children scoring far down the ladder. Japan's emergence as an economic superpower, and the US's relative decline during the last decade also fueled interest in the respective educational systems with education being seen as a causal factor (Stevenson & Stigler, 1992).

Most of the debate has so far centered on math and science achievement (Stevenson & Stigler, 1992). This is partly because math and science are valued, central disciplines in the elementary and high school curriculum in both countries. It is also because they share a common symbolic system. Mathematical and scientific notation are the same even though the concepts that are used to describe them may vary as a result of the specific language.

Explanations for the large differences in math and science achievement scores reported between the two countries have focused on the number of hours spent on the topic, the number of days spent in school (240 for Japanese children compared with 180 for US children), the relative importance of math and science to the culture, and the relative focus on individual styles versus group mastery, among others.

Art, the area with which this paper is concerned, is another discipline which bears striking parallels, and differences, in the way it is practiced and valued in the two countries. In Japan, art is a valued part of the elementary curriculum warranting as much time as science and social studies (National Institute for Educational Research, 1988). In the US, art is generally thought of as something extra to do if there is time left over from more traditionally academic subjects (Eisner, 1987; Winner, 1989; Gardner, 1989). In Japan, art is taught systematically through a series of graded textbooks. In the US, giving the children time and materials is often the method practiced, and variation between classrooms is great (Eisner, 1987; Winner, 1989). Art, like math, possesses a common symbolic system of shapes and lines that are used to construct figures and scenes used in both cultures.

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Achievement in Art

Few cross-national comparisons of achievement in the area of art have been attempted. Given the subjective nature of the discipline, finding an objective way to score achievement poses special problems. It also makes the comparison of conceptual understanding a little less clear. With math, achievement differences are well documented and conceptual knowledge can be set against this fairly well developed backdrop.

It would be reasonable to suspect, given the parallels between Math and Art in the two cultures, that art achievement in Japan would be superior to that in the US, at least in the elementary years. If more hours, systematized teaching, and an emphasis on group mastery were reasons for superior achievement in math, then they should also produce higher performance in art. It would not be unreasonable to predict that higher performance would also translate into a more advanced conceptual understanding.

Case (1993), however, suggests that achievement and conceptual development should be seen as separate. He hypothesizes that conceptual understanding should be universal in domains for which a central organizing set of structures can be identified. In math, for example, he hypothesizes that a conceptual structure underlying counting develops more or less universally, despite differences in achievement. Achievement differences are thought to be due to strategies and practice that are not conceptual in nature.

In a spatial domain such as drawing, he also hypothesizes an underlying set of spatial structures that are separate from such skills as producing well formed figures. This hypothesis suggests that the overall compositions of the drawings would be similar at the same ages in both countries, even though the quality or character of the drawings may differ (with art achievement in Japan being superior to that in the US). This is the central question that this paper seeks to answer.

In much the way that number knowledge has been used by Case (1993) to test underlying numerical structures in the area of math, representational drawing was used here to test the underlying spatial structures in the area of art. Drawing seemed the best medium for testing the spatial component both for it's ease of application and universal appeal, even though spatial structures are hypothesized to underlie other art forms as well.

Conceptual Understanding in Drawing

Okamoto (1992) tested Japanese and American children on achievement and conceptual understanding of number. She found large differences in achievement scores, consistent with a growing body of evidence, but surprisingly no significant differences on items of a conceptual nature. Conceptual items focused on questions of number that were general in nature, and often outside the realm of typical math problems (for more detail, see Okamoto, 1993). The tests of conceptual understanding were developed using Case's (1993) neo-structuralist framework. In his framework, an integrated system of numerical structures (a central conceptual structure for number) is thought to underlie understanding in this domain.

A similar framework has been proposed (Case, 1993) for evaluating children's skill in representational drawing. This framework treats children's understanding of perspective as a particular example of a much more general set of understandings that children acquire in learning to represent the location of objects in space in a systematic fashion on paper. The framework draws in a general way on the analysis originally proposed by Piaget and Inhelder (1974), which was further developed by Laurendeau and Pinard (1970).

According to the theory, children construct a set of very general conceptual structures for representing space during the early elementary years, which they then apply to a wide variety of tasks. These conceptual structures may be characterized as follows. At the *preaxial stage* (about four years of age), they are as yet unable to represent the relative height of a series of objects in relation to a mental reference axis. At the *uniaxial stage* (about six years of age) children become capable of doing this--representing the relative height of a series of objects in relation to a mental reference axis. At the *biaxial stage* (about eight) children become capable of dealing with two such reference axes. Finally, at the *integrated biaxial stage* children become capable of dealing with two such reference axes in an integrated fashion. Thus, when two reference axes are parallel (as in the case of the ground line and the horizon line in perspective drawing), they can locate the position any object must occupy with respect to these axes, and create at least some illusion of three-dimensionality.

In the domain of drawing, this general conceptual progression is believed to manifest itself as follows (Dennis, 1992). At the *preaxial* stage, children are capable of capturing the general shape of familiar objects, using a repertoire of simple forms such as circles and triangles. However, when they draw more than one object, they have difficulties drawing the two objects on the same scale, and their objects tend to hover in space. At the *uniaxial* stage, children become capable of arranging a set of objects along a ground line, and accurately portraying their relative size with respect to that line. At the *biaxial* stage, children become capable, if the task demands it, of setting up a second reference axis parallel to the first, to represent objects in the background. However, the foreground and background scenes that they draw are not yet well integrated. Finally, at the *integrated biaxial* stage, children become capable of locating the position of a set of objects with respect to both axes simultaneously, with the result that a middle ground can be rendered, in a continuous fashion, and objects can be located appropriately in this space.

This hypothesized progression was used as a basis for scoring children's spatial-drawing performance on a task adopted from Dennis (1987). The task was chosen because it required the integration of front to back and side to side relationships. It was originally developed by Dennis

(1987) to test developmental progression in drawings for a sample of Canadian children. The task had the advantage of being relatively easy to understand for the children, and easy to administer by the researchers.

Methods

Subjects

Sixty-one middle-class Japanese children were selected to participate in this study. All children within a specified age range (close to 6, 8, or 10 years) were tested from 2 schools within a large metropolitan area of Japan. The six-year-old group consisted of 19 children with a mean age of 6 yr., 5 mo. The eight-year-old group consisted of 22 children with a mean age of 8 yr., 3 mo., and the 20 ten-year-olds had a mean age of 10 yr., 5 mo.

The American sample consisted of 69 middle-class children selected for their proximity in age to 6, 8 and 10 years from 2 suburban schools in California. The six-year-old group consisted of 19 children with a mean age of 6 yr., 5 mo. The eight-year-old group consisted of 28 children with a mean age of 8 yr., 1 mo., and the 22 ten-year-olds had a mean age of 10 yr., 0 mo.

Spatial Complexity Assessment

For the task, children were given a white sheet of paper, a set of 13 colored pencils (including one standard lead pencil with an eraser), and the following directions, adapted from Dennis (1987): "Draw a picture of a mother and father holding hands in a park. Their baby is in front of them and two trees are behind them." [2] The directions were repeated to the child as often as the child and experimenter felt necessary throughout the task until the child indicated that the drawing was complete.

Each drawing was scored to correspond to the following hypothesized levels:

Level 1: Preaxial. According to the general theory, children at the preaxial level cannot yet encode and reproduce the spatial relationships in a plane relative to a mental reference axis.

The implication for this task is that, while they may draw the requested figures, they will not reproduce the relative position of these objects correctly, but concentrate instead on "filling up the page" in a fashion that they find satisfying, but which may appear idiosyncratic to the viewer.

Level 2: Uniaxial. According to the general theory, children who are functioning at the uniaxial level should be able to encode and reproduce the relative position of various objects within a single plane, relative to some mental reference axis.

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[2] For the Japanese sample, the directions were slightly modified to account for the unlikelihood that adults would hold hands in public in their culture. The altered instructions read, "Draw a picture of a mother and child holding hands in a park. A baby is in front of them and two trees are behind them."

Children at this level draw a ground line (usually in the form of grass), or clearly utilize an implicit ground line (such as the bottom of the piece of paper), and place objects of correct relative heights on this line in a series of "next to" relationships.

Level 3: Biaxial. According to the general theory, children who are functioning at the biaxial level should be able to encode and reproduce the relative position of the objects within two distinct planes, each relative to its own mental reference axis.

Children at this level create two or more axes with a series of "next to" relationships on each axis to represent the front-back relationships requested by the experimenter. Usually the second axis represents the "background" (in this case, the trees) and is placed higher on the page than the first axis (i.e., the foreground, where the couple stands). Sometimes, however, the second axis is placed at the same level and directly behind the first axis. In order to successfully represent this relationship, the couple must at least partially occlude the trees, indicating that the trees are behind the couple.

Level 4: Integrated Biaxial. According to the general theory, children at the integrated biaxial level should be able to get all the relationships within the two major planes exactly correct. In addition, they should be able to coordinate these relationships with each other in an integrated fashion. In effect, a Cartesian or artist's perspective space can be created, with the overall picture having a high degree of coherence and individual objects well localized within that whole.

Thus, the child correctly places the baby and trees in relation to the couple relative to the bottom edge of the paper and an upper horizon line. To represent the continuous space between the two axes, the child may fill in the space with grass or draw different objects, such as flowers or toys, throughout the space.

Intermediate level scores. Intermediate level scores were given to children who seemed to be in transition from one level to the next. For example, a level of 1.5 would be given to a child who attempts a single axis but is not quite successful or who forms an axis but does not draw the figures with reasonably correct relative heights.

A level of 2.5 would be given to a child who does one of the following: 1) places the people and trees on one axis and uses size to indicate that some things are further behind than others, 2) attempts a second axis but is unsuccessful in some way (e.g., attempts to use occlusion but makes the front figure transparent, with the back figure showing through), or 3) creates a second axis, but it is ambiguous to interpret (e.g., Couple on one axis; trees and baby on another axis).

A level of 3.5 would be given to a child who places the figures along one axis but uses three or more levels of occlusion to represent the requested front to back relationships. A score of 3.5 would also be given to a child who creates a continuous ground line connecting at least two axes but who does not draw in an horizon line, causing some objects to "float," or who draws figures that are placed ambiguously in relation to one another.

Figural Complexity Assessment

Drawing the human figure was thought to be the most appropriate measure of skill in this task because it required fine motor coordination, knowledge of the human figure, and ability to draw proportional relations in order to render the figure successfully. It was also one of the main requirements of this task. Drawing the figure has been shown to be a phenomenon across most cultures (Kellogg, 1967) and seemed to be equally familiar and motivating to the two samples. Finally, drawing itself has, in the past, been used to assess what has been called "Spatial IQ" (Case, 1993).

Goodenough's (1926) "Draw a Man" test was adapted to assess figure drawing skill. This test, though developed as a measure of intelligence, served well as a measure of figural complexity. A child's score is based on both number of elements (e.g., eyes, nose, feet, etc.) and ability to render more graphically accurate depictions of a figure (e.g., relative proportion of head to body). Points are also given for motor ability. Goodenough (1926) specified 51 characteristics of figure drawing that each child could either pass or fail (i.e., the child either included each characteristic or not). Scores, therefore, reflected the complexity of the figures drawn on a scale of zero to 51.

Results

Though strikingly different in appearance, the overall compositions of the pictures in both cultures did conform to the sequence outlined in Case's and Dennis' theories. This allowed for a relatively easy application of the structural scoring scheme. Sample drawings from each group at each level can be found in Figures 1 and 2.

Insert Figure 1 and 2 about here

The means and standard deviations that were achieved across age and country are indicated in Table 1. There was a significant effect for age across all subjects, $\underline{F}(2,126) = 33.36$, $\underline{p}<.001$, as expected. However, there was neither a significant effect for country, nor an interaction between age and country.

Insert Table 1 about here

Despite the almost identical compositional scores, there were noticeable differences in appearance between the drawings from the two countries. At six years Japanese children typically drew scenes that included many more objects than requested. Sandboxes, incongruously drawn from an overhead perspective, baseball diamonds, swing sets, flowers, and more filled the page. American children by comparison drew much more sparsely filled landscapes. Their minimalist drawings typically included the asked for figures and tree along a simple ground line. In a couple of the better American drawings, a sun, strip of blue sky, and 'v' shaped flying birds (all familiar icons in the landscape of children's drawings) cluttered the top portion of the page. Very few of the US six-year-old drawings showed the diversity of objects and the attention to detail found in the Japanese drawings.

At eight years of age Japanese children attempted to depict objects in three-dimensions more often than their American counterparts. In their twisted slides and strollers with splayed legs, Japanese children showed a desire to represent objects more realistically, but also an incomplete knowledge of how to draw in three-dimensions. Japanese children at eight were also more likely to draw figures in profile, from the back, and from the top. Instead of drawing cookie cutter drawings, all the same, as one might think given the rhetoric on Japanese teaching, Japanese children showed, if anything, more diversity in completing the task. Perhaps at this early level, their previous instruction provided a variety of tools for solving difficult spatial problems.

At ten, Japanese children drew more expressive figures. They used contour and shading to give their figures more volume. A cartoon-like quality typified many of them: large rounded fingers, furrowed brows, oval pupils, and triangular shoes. The American children by contrast drew figures that were less expressive and more two-dimensional.

A couple of other differences that seemed important enough to mention were the decidedly more urban looking parks drawn by the Japanese, and the large size of the figures relative to the page. Chain-link fences and asphalt were not uncommon in the Japanese drawings but absent in the American pictures.

The overall impression of more complexity in the Japanese drawings was further confirmed by comparisons using the Goodenough test. Means and standard deviations achieved across age and country are indicated in Table 2. Significant main effects were found for both age [$F(2,112) = 54.91$, $p < .001$] and country [$F(1,112) = 33.79$, $p < .001$] on the Goodenough test.

Insert Table 2 about here

Conclusions

The findings of this study, combined with the findings in the areas of math (Okamoto, 1992) and narrative (Henderson, 1993) strongly suggest that conceptual understanding is different from achievement. They also suggest that conceptual understanding is constrained by maturational as well as instructional limitations. Though the Japanese children were able to draw impressive figures complete with exaggerated features, movement, and depth, they still tended to arrange them in ways that were markedly similar to those in the US. The progression from drawing figures on one ground line, then two, is not unknown in this culture (Golomb, 1992). To find an almost identical progression in another culture with a different educational system is somewhat surprising. The task we chose was not something with which either culture should be particularly familiar, due to its spatial requirements. Because of its likely unfamiliarity (not a typical school exercise), we felt it was a fair test for comparison. These findings replicate similar findings between Chinese and Canadian children's drawings (Case, Ru, & Berg, 1992), suggesting that the effect is fairly robust.

The implications for educational practice are not "black and white." There are positive implications for both sides of the Pacific. Though more emphasis and training does not seem to move Japanese children ahead of their American counterparts in compositional complexity, the skill displayed in their drawing is to be envied. American children, though lagging behind in skill, seem to have the structural architecture in place to create more impressive drawings. All that seems to be needed for an increase in skill level is an emphasis and interest in graphic representation. Questions of allocation of resources and relative value of disciplines take on additional significance in light of this data.

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Table 1: Spatial Level Means and Standard Deviations

	Country	
Age	**United States**	**Japan**
6	2.26 (.82) n=19	2.39 (.52) n=19
8	2.91 (.56) n=28	2.93 (.60) n=22
10	3.41 (.63) n=22	3.43 (.41) n=20

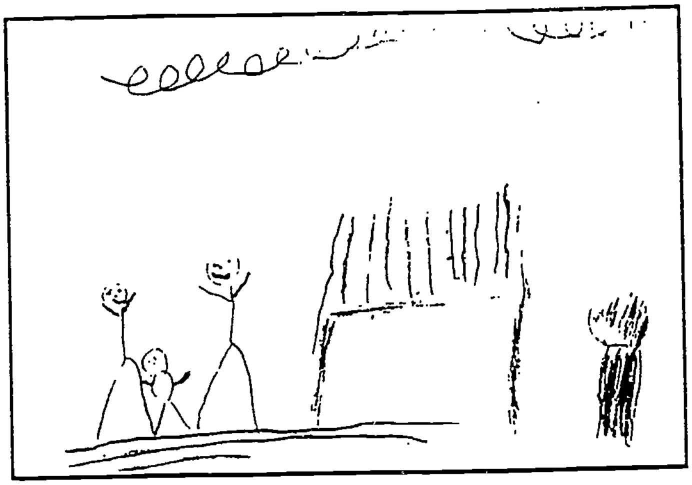
An ANOVA showed no main effect for Country and a main effect for Age, $F(2,126) = 33.36$, $p < .001$.

Table 2: **Figural Score Means and Standard Deviations (Goodenough)**

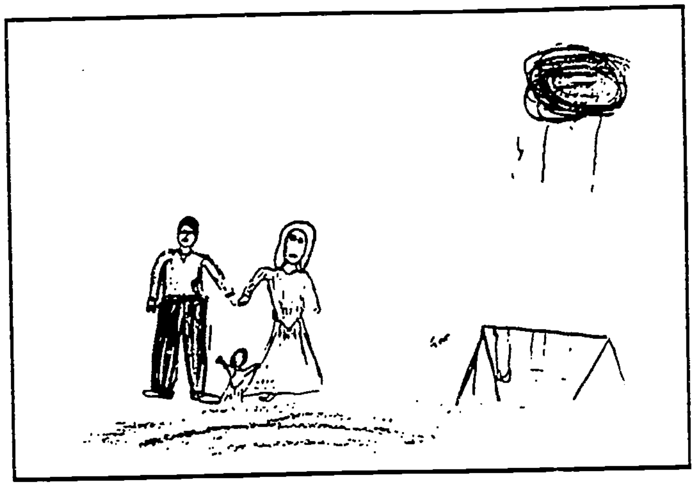
	Country	
Age	**United States**	**Japan**
6	17.16 (7.0) n=19	20.9 (6.3) n=19
8	23.3 (5.4) n=24	31.4 (5.2) n=21
10	30.0 (6.5) n=17	36.7 (3.3) n=16

An ANOVA showed a main effect for both age [$\underline{F}(2,112) = 54.91$, $\underline{p} < .001$] and country [$\underline{F}(1,112) = 33.79$, $\underline{p} < .001$].

Figure 1: Sample American Drawings by Level



Level 2



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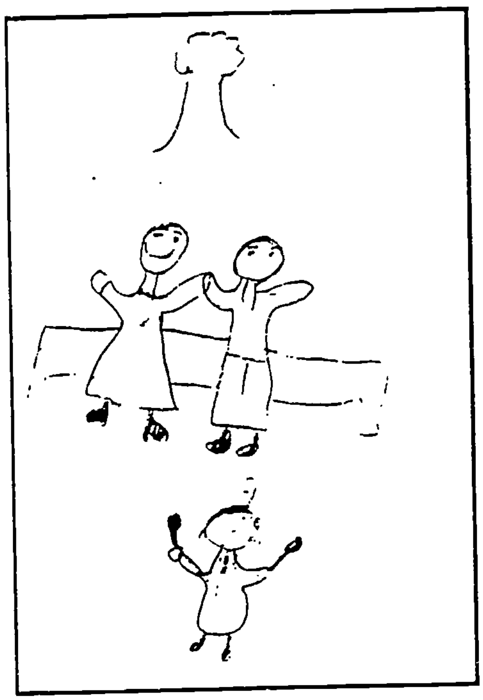
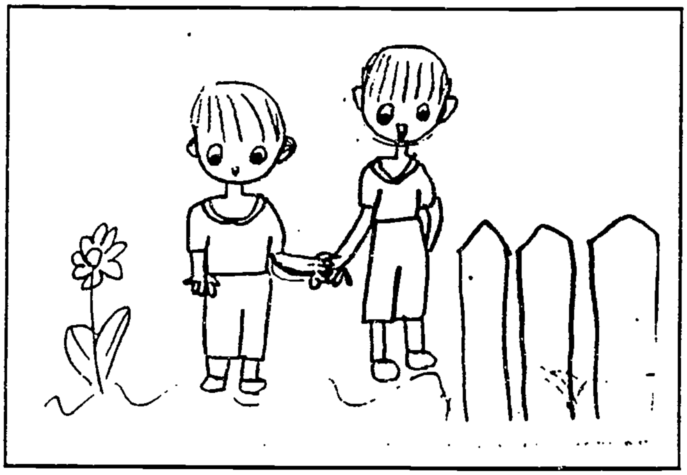


Level 4

Figure 2: Sample Japanese Drawings by Level



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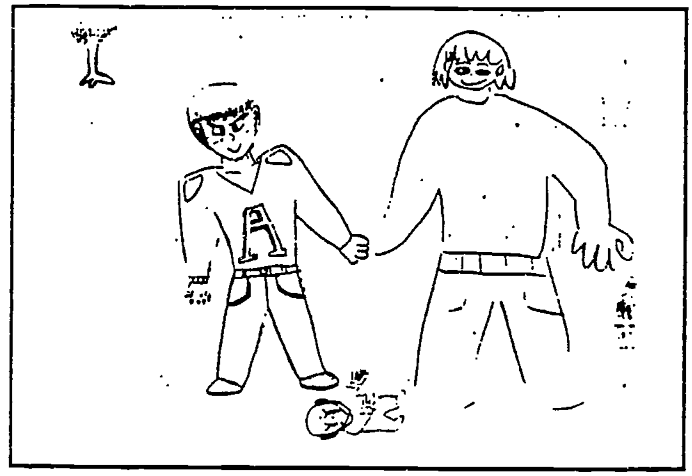

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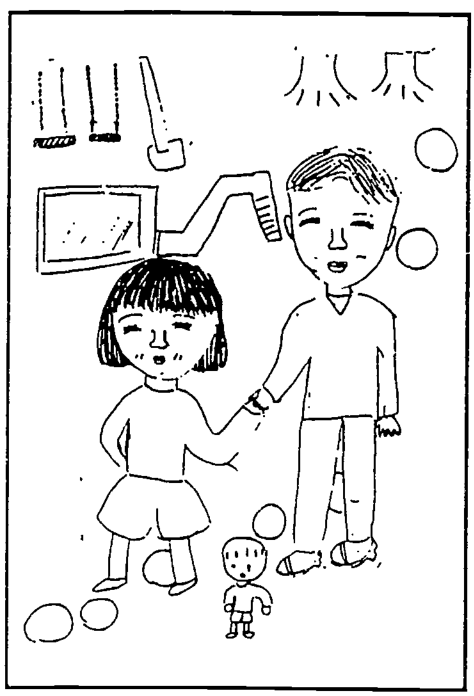

Level 4