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The Study of Spatial Relation and Orientation in Children

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***Abstract* – The goal of the research is to compare the differences and similarities between different cultures in pedagogical approaches for teaching spatial concepts to young children and to develop a pedagogical approach that not only promotes spatial orientation competence but also appeals to a broad spectrum of students including diverse racial and ethnic groups. We applied a mixed methodology (quantitative and qualitative). Results revealed that in terms of the spatial orientation teaching of different ethnic groups, cultural factors influence the spatial performance of young children. Similarity in instruction is more effective in helping children develop a spatial reference frame for use.**

***Keywords* – Spatial Concepts, Young Children, Cultural Factor.**

I. THEORETICAL FRAMEWORK

The spatial competence of children is a key aspect that determines progress in science and in art. It also helps children to reason, gain knowledge, formulate questions, and develop the ability to solve problems. If children have difficulty with spatial concepts, it is likely that they will have difficulty in the academic environment and possibly in daily life as well. Before studying geometry, one must have developed their spatial competence. A lack of understanding of spatial relation and orientation is a disadvantage for children when they begin to study geometry.

Spatial concepts include spatial relations and spatial orientation. Spatial relation is made up of spatial location, direction, and distance. Spatial relationship is defined as an understanding of the relationship between objects in space, in both dynamic and static environments. The concept of spatial orientation also includes an estimation of the distances, dimensions, shapes, and mutual positions of objects and their positions with respect to the body of the onlooker [8].

A. Spatial Concepts of Location

Reference [4] pointed out that children younger than two years reflect poor spatial awareness or memory when they retrace simple spatial displacements compared to older children. Moreover, reference [7] found that younger children are less in solving problems relating to location as they have not yet fully developed their spatial cognition. Left-right spatial orientation is difficult for children in grades above kindergarten, but front-back spatial orientation is easy for kindergarteners and first graders. However, if children use a reference system with a fixed point of reference to assist them with orientation, they could determine direction more easily. Reference [7] concluded that landmark information is a key factor in orientation for children. Landmarks, such as a sign or an object to help the child know where he is, can provide a proximal clue to connect the goal and distal information about distance to the goal. Reference [1] explained that children use the following three reference frames: the self, the other person, and the landmark. Additionally, reference [9] remarked that there are three types of references that can be used to describe location: the relative frame of reference, the intrinsic frame of reference, and the absolute frame of reference. The absolute frame of reference is based on cardinal directions, such as “the cat sits north of the chair.” The relative frame of reference is based on body axes, such as “the laptop is to the left of the chair (from my viewpoint).” The intrinsic frame of reference uses a landmark to describe the location, for example, “the lamp is at the chair’s front.” However, for child development, reference [16] asserted that children apply the self-frame when they first start to understand location, then they use the other person, and finally they use landmarks to find locations. In addition, other researchers stated that younger children refer to their kinesthetic and visual analyzers to know their locality. Although the development of a reference of system is important for children to determine orientation, as children’s age increases, the development of spatial orientation becomes based on the use of different reference systems, which include self-reference (other people), cardinal reference (verbal system), and landmarks to assist their orientation [8], [15].

As for learning about distance to establish location, children do not understand distance scaling until 10-12 years old. In fact, reference [6] found that children 2-3 years old can point out where hidden objects are. Moreover, they found that 7-month-old infants can also do the same well. Further, children 4-5 years old can reproduce configurations of objects from a map referring to the object’s symmetry, but cannot accurately scale objects from maps [17]. However, reference [6] found that 4-year-olds and the majority of 3-year-olds can understand scaling in simple maps and use that to locate objects in a sandbox.

Recently, research has shown that spatial location knowledge depends on intentional learning [2], [3], [12]. Evidently, these results contrast with Piaget’s opinion that the development of a child’s concept of space relies on age or maturity [14]. Children’s spatial competence has been thought of as a late-accessed skill, emerging at about 6 or 7 years old[18]. However, reference [10] found that 8.5-month-old infants are able to use landmarks relationally. These results show that children’s spatial concepts could be acquired from teaching, which provides orientation strategies for children to determine spatial relation.

B. Spatial Concepts and Culture

Different cultures develop spatial concepts differently. Reference [13] compared the spatial concept knowledge

of 10-year-old children of Appalachia to that of suburban and urban children, and found that Appalachia children have better-developed spatial reasoning than the others. This result suggests that cultural factors influence spatial cognitive performance in children. Furthermore, spatial behaviors are related to orientation strategies, and spatial clues could supply structure by acquiring information on distance and direction. Reference [8] addressed how children perceive an object and associate spatial concepts to language.

Moreover, language is a component of culture, and culture also influences spatial orientation performance in children. Reference [11] conducted cross-cultural experimental research on the spatial orientation of children. They found that language is the main factor impacting children's spatial orientation in India and Nepal. Children of different cultures use different references to organize directions. It would be interesting to know how children develop their spatial concepts, such as spatial relation and orientation, in different cultures.

C. Prospective Perspectives of Teaching

Reference[19]demonstrated that spatial location precise over development through enhancing working memory. They conducted research on the experience-dependent effects on direction. In both children and adults, they found that more experiences result in more errors made in the direction responding to location. Otherwise, experiences could change the limitation of spatial developments. According to Van Hiele's structure and insight on perspective and Vogtsky's social cultural factor [20] [21], spatial concept teaching can be applied to preschool children, if children construct their learning style based on spatial concepts. To help young children master spatial performance, the current researcher collaborated with teachers to design a spatial concepts curriculum. Consequently, the differences between Taiwanese and US teaching methods in spatial concepts for children were explored. The research on spatial concepts focuses on spatial relations and spatial orientation competence. The following research questions were examined:

1) Are methods of teaching spatial relation and orientation to children different in Taiwan and the US?
2) How do students perform in spatial competence?
3) What cultural factors influence the different performances of spatial competence in the children of Taiwan and the US?

II. METHODOLOGY

The research combined qualitative and quantitative methods to meet the research objectives. Research methods included case study, experiment, and ethnography. Observation, interviews, and testing were used to collect data. The research was conducted at the University of Laboratory School (University of Hawaii) in the US and TUK (Tainan University) in Taiwan. The researcher selected one class from both kindergartens, observed the students' performance in spatial relations and spatial orientation, and recorded the teacher's instructions. Concerning the number of students in each class, the UHK has 20 students who come from diverse ethnic and socio-economic backgrounds. All students were selected from different ethnic groups (e.g., the original inhabitants, Caucasians, immigrants). TUK has 30 students who are all native students. The researcher gave some tests to the children to determine whether the research design would improve their spatial competence. The researcher spent three months observing the class in each school.

Observation was used to understand the development of spatial concepts in kindergarteners and the instruction of spatial concepts. The researcher designed spatial lessons for kindergarteners to learn the spatial concepts of spatial relation and orientation. The curriculum integrated different subjects into each lesson. One was designed for the UHK class for two weeks (i.e., teach a spatial concepts lesson every day); another was designed for the TUK class for one month (i.e., teach a spatial concepts lesson twice a week).

Before intervention, the researcher conducted a pre-test and a post-test of spatial concepts with the children in both kindergarten classes. The evaluation took place in the classroom. The criteria of the evaluation were based on the "Spatial Concepts Assessment Scale," which the researcher developed in Taiwan. The number of days between the pre-test and the post-test for children was almost two months in Taiwan, and one and a half month in the US. The assessment was a set of performance tests. Each test took two days to finish. The scale was adapted based on cross-cultural differences to test the UHK students. Following the evaluation, the researcher organized and analyzed the data and performed a comparison between Taiwan and the US to respond to the research questions.

III. RESULTS AND DISCUSSION

The following areas reveal the factors that affect spatial orientation teaching and learning in different cultures: school curriculum, lesson plan, and learning style.

A. School Curriculum

The UHK kindergarteners and first graders are mixed together to learn all subjects except mathematics. Each class has 45-minute lessons five days a week. The kindergarten teacher does not feel pressure from parents' expectations.

"I don't think parents have more expectations for teachers in my country. They don't care what their children learn in the school" (UHK teacher, 10/08).

As a result of this lack of pressure, the teacher develops the curriculum by herself for her students.

The TUK implements different kinds of subject curriculum from the University, for example, art, dancing, physical education, and a preschool program. Normally, at the end of each semester, the school teachers of different grades meet together to discuss the new curriculum for the coming semester. The goal of the curriculum is set according to the needs of the students in each grade. The kindergarten teachers decide on four to five themes to teach for the whole semester, but most of the themes are

selected from commercial textbooks. The school buys these textbooks for the teachers and practice notebooks for the children. The teachers refer to these textbooks to make their lesson plans. Regardless of the chosen curriculum, the expectations of parents cannot be neglected in deciding school curriculum. Taiwanese parents expect their children to learn language and mathematics more than other subjects.

"Parents would ask their children what teachers taught and how much homework they gave for math and reading every day. We should give several lessons on math and language" (TUK teacher, 03/20).

Under these circumstances, there are a significant number of periods for children to learn language and mathematics in the school curriculum. Consequently, children have many worksheets and homework to learn both subjects.

In comparing the two school situations, it is obvious that both schools do not follow state or national curriculum to decide their school curriculum, and instead have their own curriculum. Generally, the US schools are under strong government pressure to bring parents into a more effective and involved educational partnership with schools [22]. The UHK curriculum is not restricted by outsider factors such as parents. The teacher has full autonomy in her own teaching. As for TUK, although Taiwan does not have an educational partnership with parents as in the US, decision-making over curriculum in Taiwan is strongly influenced by parents' expectations. Moreover, the teacher's profession is one of the factors impacting how the school curriculum is designed. Another factor is that teachers are too reliant on commercial textbooks; as such, they miss opportunities to design school curriculum and are bound by commercial publishers' curriculum.

B. Lesson Plan

The current researcher collaborated with teachers to make lesson plans for the class in order to compare the teaching and learning of spatial concepts for children in both countries. Based on the research findings, the researcher gave some ideas about key spatial concepts for their teaching. In order to integrate other subjects into these lessons, the researcher developed themes: TUK's theme was "bugs" and UHK's theme was "Thanksgiving." The TUK teacher combined spatial concepts and ladybugs in a one-month lesson; the UHK teacher taught spatial concepts and integrated other subjects into the spatial concepts lesson.

Table 1. Lessons for the UHK

Activity	Subject	Learning
1. Self-Tree	Movement & Math	Know where the eyes, head, hands, and legs are
2. Walk around		Back to the starting spot
3. Hokie-Pokie		Rotation in three dimensions
4. Run outside		Opposite direction
5. Mother, may I?		Rotation in three dimensions
6. Simon says		Telling right and left apart
7. Twister		Practice right and left movements (spinner)
8. Arrange the tile	Math	Spatial relation problem-solving
9. Draw on paper	Art	Label left, right, top, and bottom
10.Draw on a board and play a game	Art & Math	Spatial orientation in two dimensions
11.Board game with dices	Math	Spatial relation and orientation
12.Tile sits in which hand?	Math	Telling right and left apart

Before giving instructions, the teacher tied the children with yarn: red yarn on their right hand, yellow yarn on their left hand. The UHK teacher repeated "Walk around" and "Hokie-Pokie" in the first four days. The UHK teacher designed several kinesthetic activities for the children. Put your right (left) hand in; put your right hand out.

Put your right (left) hand in, and shake it all about.

Do the Hokie Pokie and turn yourself around. That's what it is all about, hey! (UHK teacher, 11/03)

The TUK teacher's first lesson of spatial concepts taught locative words. Then, the teacher strengthened the children's kinesthetic and visual practice with action.

Table 2. Lessons for the TUK

Activity	Subject	Learning
1. The princess of Giraffe Kingdom	Language & Math	The words "Top and down, front and back, left and right"
2. Mother, may I?	Movement	
3. I am a butterfly	Music & Movement	Learn spatial direction and orientation
4. Model show	Movement	Orientation in three dimensions
5. Make a crown and draw pictures	Art & Math	Orientation in two dimensions
6. Live in the palace	Math	Solving problems in three dimensions

Looking at the two lesson tables, TUK moved from the abstract to the concrete to facilitate the children's learning of spatial concepts. In contrast, UHK moved from the concrete to the abstract. In the last lesson, both teachers asked the children to solve problems. However, Reference [8] pointed out that children's orientation requires a verbal system to identify locality. Thus, it is necessary for students to learn spatial direction words, such as "top," "bottom," "front," "back," "left," and "right," from the beginning in order to learn spatial concepts. The UHK teacher did not teach the students these words but helped them to learn through the activity. The teacher thought, "Kindergarteners are so young that it might not be suitable to teach the positional terms" (UHK, teacher 11/04)

C. Learning Style

1) *Reference Systems*

The UHK children learned their spatial orientation in a circle. In the circle, some children faced the teacher. While the teacher directed the activity of "Hokie-Pokie," she asked the children to raise their right hands. However, the teacher showed her right hand without informing the children that it would be the opposite hand for them. It is important that children have a correct reference systemto guide their orientation. Particularly in the beginning stage, the teacher should have given the children a correct

reference, but the teacher did not realize this and she demonstrated the opposite hand for the children.

In contrast, when the TUK children learned their spatial orientation, the teacher taught them in a row. The teacher showed the direction of right or left in front of the children using the same hands as the children. When teaching, first she faced the children, and then she turned her back to them to raise her right hand. Finally, she asked the children to raise their right hand to do the same gesture as she did. In this way, the children received the correct reference with which to determine their orientation.

2) *Teacher's Attitude*

Moreover, when the UHK teacher conducted the spatial concepts lessons, she gave the children the choice to watch or to do other activities. Naturally, some children did not attend the lesson; instead, they played in the classroom. Therefore, some of the children missed the chance to learn this key concept. When they practiced in the class or took a test afterwards, they had problems with orientation.

In contrast, when the TUK teacher led spatial activities, children paid attention and joined in the activities. None of the children missed the opportunity to learn key spatial concepts, since the teacher did not allow the children to miss learning opportunities. The teacher always reminded the children to concentrate on learning the concepts fully.

3) *Language*

In the sensory stage, the children memorized their location through language. Children perceive objects and associate spatial concepts with language [5] . If children can use a reference system with a fixed point of reference to assist them with orientation, they could determine direction more easily. The UHK teacher did not show the students locative words in Math class; instead, she used activities to help them understand location. The teacher thought that the kindergarteners were too young and that it might not have been a good idea to teach them words of spatial direction. It is not surprising that the UHK children flipped their numbers and characters during writing. Even though this situation happened frequently, the teacher did not correct them.

Chinese characters look like pictures, and the position of their components is related to spatial location. The component's positions cannot be written in the wrong direction. If they are put in the wrong direction, the characters become different words with different meanings. In fact, while children are learning characters, they are learning spatial locations indirectly. When the teacher taught spatial concepts, she encouraged the students to memorize the locative terms and practice in various ways outside of class.

Reference [9] suggested that not all languages make use of all frames of reference. While the TUK teacher taught the relative frame of reference through language (Chinese characters) the UHK teacher taught children direction through the movement of activities. Not all relative linguistic systems are the same. "The bottom of an object" in Taiwan means "under the object," but there are three words to represent this, such as "under," "bottom," and "beneath." One of the Caucasian students in the UHK class overlapped two tiles together after the teacher ordered, "Put your blue tile under your red one."

4) *Evaluation*

Piaget pointed out that children cannot perform spatial competence until they are nine to ten years old [23], but reference [20]disagreed. Furthermore, He suggested that children are capable of promoting their spatial abilities from learning. In order to know the students' potential and competence in spatial concepts, the current researcher used the "Spatial Concepts Assessment Scale" to evaluate their spatial competence before and after learning the planned lesson. Table 3 shows the pre-test scores of the two countries' children in spatial competence.

Table 3. Comparison of pre-test spatial competence

Spatial	School	Pre-Test		Post-Test	
		UHK	TUK	TUK	UHK
Front-bottom		11.91	11.30	12.00	11.60
2. Top-bottom		5.91	5.80	6.00	5.70
3. Inside-outside		5.89	4.80	6.00	6.00
4. Three dimensions		7.70	5.30	9.00	6.10
5. Two dimensions		7.76	5.30	9.00	6.30
6. Egocentric reference		8.03	6.00	9.00	7.00
7. Horizontal direction		5.67	4.40	6.00	5.00
8.Left and right rotation		7.61	5.10	9.00	5.80
9.Set landmark to left and right		4.58	2.80	6.00	3.90
10.Set landmark to front and back		5.10	3.00	6.00	3.80

Table 3 shows that Piaget's theory does not correlate with the research result. Children have spatial concepts and can perform well before they are nine to ten years of age. Simultaneously, the result supports the opinion of Van Hiele because the post-test scores are higher than the pre-test scores.

Though there are differences between the individual teachers under comparison, there are similar trends across their instruction in all four contexts regarding the factors that might either support or undermine kindergarteners' learning of special concepts. The following will discuss cultural factors, which impacted the students' performance in spatial concepts.

D. Constructing Knowledge

The UHK teacher believed that knowledge could come from the construction of peer learning and not merely from the teachers (UHK, 11/11). She encouraged children to use alternative ways to solve problems. In contrast, the TUK teacher thought that the teacher had to provide children with the correct knowledge and opportunities to learn (03/24).

Furthermore, in terms of cultural differences, Asian students respect authority more than US students do. This means that Taiwanese students gain more knowledge from authority than through their own observations. Keeping quiet and sitting still in the classroom are necessary for students in Taiwan. In contrast, talking and playing around are common in the classroom for UHK students; as such, they have short attention spans for learning.

These situations are relevant for the role of a teacher. Classroom management is teacher-centered in Taiwan but student-centered in the US. As Taiwanese students sit in a row instead of sitting in a circle, it is easy for teachers to

control the classroom.

Different cultures have different values. The UHK teacher gave the children the choice to learn spatial concepts, while the TUK teacher requested that her students learn spatial concepts. The teachers' attitudes and values thus influenced the evaluation results of the scales.

E. Creativity

Regarding the pedagogic approach, conformity was important for the Taiwanese teacher; she focused on the same learning styles for the children, and thus could not include creative activities in her lessons. Simultaneously, she spent time asking children to memorize the locative terms. Thus, the children performed well on tests. Not only was she concerned about conformity of learning, but she also followed the current researcher's ideas in planning lessons. She integrated other subjects into her school theme of "bugs" to teach spatial concepts. It was a challenge for her to apply new teaching strategies in her lessons.

In contrast, intriguing children to learn was the purpose of education for the UHK teacher. She designed creative activities from her experiences and did not follow the current researcher's ideas in designing lessons. She also did not ask students to memorize any positional words. She thought, "Learning can occur in the natural context, and learning comes from motivation" (UHK teacher, 11/09). The UHK lesson plan was not related to an integrated curriculum that was connected to other subjects; it also did not incorporate the school theme of "Thanksgiving" to teach spatial concepts. Hence, conformity or creativeness depends on the cultures of both countries.

IV. Conclusion

The comparison of two countries in spatial concept teaching gives a clear outline of the differences. According to child cognitive development, children organize their spatial relation first with sensory skills, then with verbal skills, and lastly, by using a symbolic reference system. The Taiwanese teacher taught spatial concepts in the reverse order. The Taiwanese teacher emphasized teaching spatial language before movements. When children learned spatial direction words, they were able to follow and understand spatial concepts easily. In contrast, the US teacher focused on kinesthesia to build spatial concepts.

Regarding children's learning, the result suggests that the basic benchmark of spatial concepts is the same for all children. Children 5-6 years old can distinguish between top-bottom, and front-back. The more familiar children are with spatial concepts, the more they can go from turning back to the initial point, which is the reference frame of orientation. Whether spatial concepts can be taught to children in an early age yields various results. The present findings could allow curriculum designers to consider the inclusion of spatial concepts in the curriculum and help students build a solid foundation in spatial concepts.

The results of this cross-cultural research on comparative pedagogy show that cultural factors cause differences in the spatial concept instruction of children in the areas of school curriculum, lesson plan, and learning. To conduct a proper analysis of pedagogy in light of culture, researchers can use the present findings as a frame to examine other dimensions in education, such as math, units, and themes. As the researcher has shown, the current research not only focuses on pedagogical diversity and commonality across cultures, it also comes close to identifying the truth of the development of spatial concepts in children.

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