featured articles

RELATING COGNITIVE DEVELOPMENT TO CARTOGRAPHIC EDUCATION WITH A MODEL OF ORIENTATION SPACE

An "orientation space" is briefly described as a means of synthesizing a vast literature and of providing psychologists and cartographers with some common ground for discussing the issues of cognitive development in children as they might apply to elementary cartographic education. The vast literature refers to the work in many fields on the questions of how children navigate and orient themselves, how they visualize and organize space and spatial relationships, and how they express these ideas graphically.

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INTRODUCTION AND CONTEMPORARY BACKGROUND

During the last decade there has been great interest in geographic education and the role that mapping might play in its rejuvenation. Unfortunately, many of the new initiatives and teaching strategies generated do not make reference to the great body of literature on cognitive development. In a session at the recent NACIS meeting in St. Paul, five psychologists associated with the Institute of Child Development at the University of Minnesota made presentations based on their work. In particular, the participants were interested in learning more about such questions as how children navigate and orient themselves, how they visualize and organize space and spatial relations, and how they express these ideas graphically. Continuing from these questions, what ideas might be developed that would have significance for elementary cartographic and geographic education? This paper, which introduced that session, describes an "orientation space" which may encompass many of these questions and thus provide some common ground for both cartographers and psychologists.

In planning this session, I drew on my interest in the work of Dee Joy Coulter. Trained in special education, neurology, and holistic education, Ms. Coulter has taught courses on right brain/left brain and the neurology of learning in the Department of Psychology at the University of Northern Colorado. In a paper published in 1985 by the American Orff-Schulwerk Association, entitled, "The Brain's Timetable for Developing Musical Skills," she describes stages typical of the brain's growth and links them to skills related to auditory perception. From this she considers what instructional strategies might relate to these various stages of neurological readiness. For example:

> 1) In regard to kindergarten to 2nd grade children (ages 5 - 7), she states (Coulter 1985 90)," ...the child is incapable of separating the information coming in from the motor activity going out. Until midway through the 6 to 8 year old brain growth spurt, learning remains inextricably linked to movement."

This is the essence of the Orff-Schulwerk "process" pedagogy of music and movement for children. In this process, children often find themselves in environmental situations that involve the need to orient themselves and "navigate" through created worlds. This suggests that one formal aspect of environmental education should begin with movement within various environmental settings, and that we acknowledge this beginning by finding ways to relate it to our more established educational goals.

> 2) In regard to 2nd to 3rd grade children (ages 7 - 9), Coulter states (Coulter 1985 91), "Math, phonics and music notation [and dare we add cartographic notation?] involve skill in linking visual to auditory centers within the brain. Children must discover that math symbols, phonics and musical notations are all reversible code systems. They must learn to play with these codes easily, translating from visible marks on paper to a grasp of the sounds those marks represent and from the musical and spoken words back to their visual code forms."

She continues (Coulter 1985 91), "The music educator is faced with a curricular dilemma in addressing 6 and 7 year olds. When should this "code work" be introduced? By postponing this task as long as possible, ideally until age 8, and substituting active performance experiences based on imitation, rhythm and movement strategies, the joy of music is kept alive. As the Orff-Schulwerk approach has so ably demonstrated, enjoyment and success in early music experiences is much more likely to stimulate a long term commitment to music education than early exposure to music theory and the mechanics of reading musical notation."

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Surely there is more to cartographic notation than some rules of historic convention. The suggestion here is that all code systems are interchangeable and expressible in many different forms. Cartography is in the enviable position, if we would only acknowledge it, of being able to demonstrate this. So much of our work involves expressing information variously in both digital and analog forms, and in numerical, verbal and graphic terms. One is tempted to paraphrase Coulter and ask: "By substituting active performance experiences, can the joys and skills of exploring the environment be kept alive more successfully than by too early exposing our students to cartographic theory and the conventions of formal maps?"

What might these active performance experiences be? On what basis do we organize them? Should we be looking for a parallel neurological explanation for the development of visual and graphic skills? Or are there other foundations on which to address this question of performance experiences?

My first attempt at seeking an answer to these questions took the form of a diagram (Figure 1). In it I tried to relate some of the items that we recognize in our various geographic and cartographic curricula with some general topic areas that might be of common interest to researchers in the many disciplines that consider human interactions with the environment. The three general areas (Navigation, Visualization, and Graphic Expression) can be broken down into more specific topics of inquiry. But the key connections that allow links to be made across the diagram are what I call the intellectual or perceptual bridges in Column 3. Many of these are familiar as the subjects of research from the extensive literature in such diverse disciplines as art, cartography, child development, geography, landscape architecture, and the many sub-disciplines of psychology. As far as I know, none of the elements of our cartographic curricula have any acknowledged foundation in the fundamental concepts that arise out of

GENERAL AREAS	SPECIFIC TOPICS OF INQUIRY	INTELLECTUAL OR PERCEPTUAL BRIDGES	GEOGRAPHIC-CARTOGRAPHIC CURRICULA ITEMS
NAVIGATION	ORIENTATION MOVEMENT POSITION	•FRAMES OF REFERENCE: EGO-CENTRIC & GEOCENTRIC (relative, absolute) •ENVIRONMENTAL CLUES: shadows, gravity, distance, size constancy •LANDMARK DIFFERENTIATION •STRUCTURAL & ORGANIZATIONAL FEATURES OF LANDSCAPES •AFFORDANCES & THEIR ASSOCIATED INVARIANT RELATIONSHIPS •TRANSFORMATIONS W/IN THE FLUX OF AMBIENT LIGHT	•CARDINAL DIRECTION •COMPASS USE •POLAR COORDINATES •TRANSFORMATIONS •MAP PROJECTIONS •CO-ORDINATE GEOMETRY (alpha numeric grids) •LATITUDE/LONGITUDE
VISUALIZATION	OBJECT PERCEPTION EUCLIDEAN SPACE NON-EUCLIDEAN SPACES NUMERICAL RELATIONSHIPS	•MEMORY: TEMPORAL ORDERING & SPATIAL DIFFERENTIATION •PROCEDURAL & SURVEY KNOWLEDGE •ESSENTIAL CHARACTERISTICS •INVARIANT DIMENSIONS & RELATIONSHIPS (shape constancy) •DEPTH PERCEPTION & THE METRIC OF SCALE CHANGE •METRIC RELATIONSHIPS •ARITHMETIC LOGIC & NUMBER SKILLS •INFORMATION SCALING	•SYMBOLIZATION •GENERALIZATION •REGIONS:taxonomic & hierarchical •CARTOGRAMS •CARICATURES •MAP PROJECTIONS •SCALE AS A POINT PHENOMENON •STATISTICS •SPATIAL STATISTICS
GRAPHIC EXPRESSION	GRAPHIC SCALING {ENCODING, DECODING} HIERARCHICAL SCALING {PLANAR, VERTICAL} REPRESENTING SPACE	•RIGHT BRAIN ANALOGIES TO LEFT BRAIN STATISTICAL PROCEDURES •COLOR AS A 3-D & TEXTURE AS A 7-D PERCEPTUAL PHENOMENOM •"PERCEPTUAL DIMENSIONS" OF OBJECTS AND SURFACES •GESTALT GROUPING PRINCIPLES •SIZE DISCRIMINATION: Steven's power functions, jnd's, lpd's •FIGURE GROUND •LANDSCAPE DRAWING •ANALYSING GRAPHIC IMAGES	•CARTOGRAPHIC DESIGN •COLOR USE •SYMBOL DESIGN •LETTERING DESIGN •PROPORTIONAL POINT SYMBOL MAPPING •DOT MAPPING •BASE INFO/SUBJECT INFO •PERSPECTIVE DRAWING •USING MAPS & GRAPHIC •BLOCK DIAGRAMS

Figure 1. A table of areas of potential interest to psychologists and cartographers, items from geographic-cartographic curricula, and some intellectual and perceptual bridges which may link them.

our early visual transactions with the world. I have been arguing (1990) that perhaps they should.

More recently, I have been working with a simple model of the potential interaction between cartographers and psychologists (Figure 2). This model is derived from a broad view of orientation which may in itself subsume all of the areas of our mutual interest. In the formal sense, we are concerned with three needs in human orientation:

1) How we achieve various levels of accuracy, in specifying position, that are appropriate to our actions and needs.
2) How we convey this information to other people, to increasing numbers of them, some remote from us.
3) How we obtain and manipulate feedback from the environment to be used in meeting these first two needs. This problem is exacerbated by a number of factors such as changing task demands or increases in our speed relative to the environment, in the complexity of our surroundings, or in the extensiveness of the area.

The arrows along the three axes reflect gradients of increasing needs. But it should not be implied that higher level solutions should always be pursued or are the hallmark of the expert orienteer. Rather our goals in education should be to acquaint students with a broad range of techniques which they can apply selectively to various levels of need and to introduce these techniques to children in developmentally appropriate ways.

These three needs can be represented as intersecting axes which collectively define the cubical "orientation space." I use the term orientation here in its broadest sense. That is, in order to establish the position of ourselves and of objects external to us, we must come to appreciate how we interact with our environment, how we visualize it, and how we might

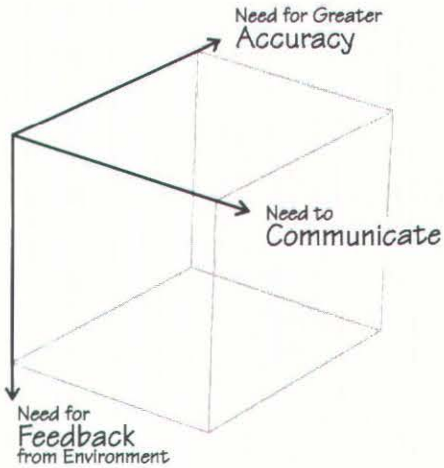

Figure 2. An "orientation space" defined by the three needs in human orientation.

represent important elements or relationships within it. Let us examine the three facets so defined: the top, back and near side.

The relationship between the needs for accuracy and communication (the top facet) forms the basis of much of our traditional curriculum in cartography. It is crowded with techniques for angular measurement and systems for organizing space, particularly at medium and small, i.e. global scales. They all begin with the problem of an individual, without instruments, establishing positions within a landscape relative to and for the benefit of him or her self. The work of James Gibson suggests that this is closely related to our sensitivity to, and use of, structures in the flux of ambient light (Heft 1981 236). For example, environmental textures created through ambient light playing or casting shadows upon surfaces allow us to perceive how far away an object is or what form those surfaces take.

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At some level of need, observers must begin to use landmarks external to themselves. Further, as the number of observed points and landmarks increases, we need some kind of document to keep track of all these points and their positional interrelationships. Just how geodetically correct these documents must be is a moot point. But clearly some kind of map-like document is needed.

Eventually, as distances increase so that we can no longer view the entirety of space or see others with whom we wish to communicate, we come to use what I call universal landmarks– the sun, and stars like Polaris. With these we can communicate accurate information about global positions to anyone who shares knowledge of the system being used.

A second facet (the back one) of this orientation space is described by the interaction between the needs for accuracy and for better feedback from the environment. This feedback may also be coming from a physical or mental representation of the environment in which we are at rest or through which we may progress by walking, then running, and finally to "flying" in both its literal or figurative senses. To me, the essence of this transaction involves the change from our general use of peripheral vision to the need to have more focused vision and finally to rely upon some kind of instrumentally assisted vision as we change the types of landmarks utilized. The lower right-hand section of this facet is clearly in the high-tech domain of remote sensing, radar, satellites, and digital imagery.

The other two facets involve more right brain ways of knowing (the way most of us interact with our environments)– ways that are holistic, intuitive, spatial, and non-verbal.

The third facet (the near or facing side) is described by the interaction between the needs to communicate and that of obtaining useful environmental feedback. Crucial to feedback is how we organize space and objects within it, e.g., categorical or spatial. I suspect that most of the psychological research aimed at modeling the interaction of humans with their environments takes place in this facet. Further, it takes place primarily at large, i.e., local scales or even in interior sites. The essence of this interaction may be related to the kinds of information required for the communication of more specific locational information. These may vary from explicit geographic facts to implicit or relational information, such as the perceived functional characteristics of the environment, its affordances.

For my part, I see the top facet (Accuracy vs. Communication) as being very much a left-brain domain of systematic, analytic, mathematical, and logical ways of processing information, at least in the ways we teach about these things. The other two facets involve more right brain ways of knowing (the way most of us interact with our environments)– ways that are holistic, intuitive, spatial, and non-verbal.

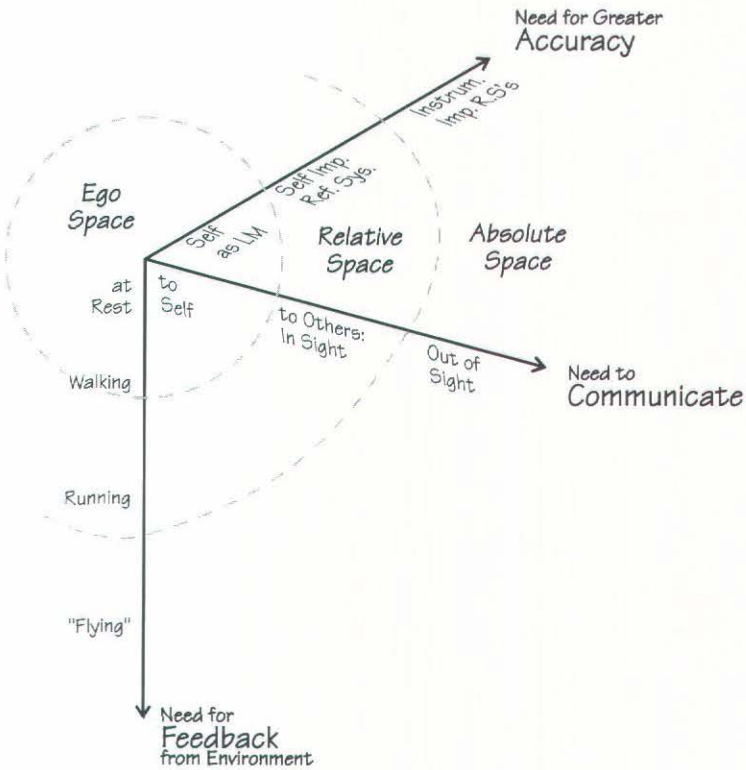

Figure 3. The "orientation space" in greater detail. The origin, or top left corner, of the orientation space suggests the convergence of these three needs in the "ego-space" of an individual at rest, communicating positional information to himself, and using himself as landmark. From this situation there is a hierarchy or continua of scales out into relative and absolute space where such communication may be to others (often out of sight) and with greater levels of accuracy.

The top surface of the "space" makes reference to a sequence of techniques, which make possible more accurate orientation, beginning with the use of oneself as a landmark, to self imposed reference systems (e.g., using clock-face directions), to instrumentally imposed reference systems with external landmarks. The near side facet makes reference to the sequence of problems in communicating first with oneself, then to others, in sight, and finally to those out of sight. Also, there is the suggestion that the need for, and form of, feedback changes as one's speed relative to the environment increases.

The combination of these three facets defines in Figure 3 an orientation space in which a rough hierarchy or continua of scales is suggested. The hierarchy originates at the "ego space" of an individual observing or moving about a relatively limited environment. It is a place where affordances structure our individual worlds. Representations of these worlds are scaled to personal values and reflect individual experience.

At the extremities of the orientation space, there is "absolute or formal space" where we measure precisely and we employ systematic ways of defining space and positions within it, using universal landmarks. It is a space we probably only experience indirectly and abstractly. Representations of it are scaled to logical geometric properties and mathematical measures.

In between is the "space of relative position," where meanings are derived from the relationships of positions, not of their absolutes. It is the most important and familiar space for it is here that most of our actions and thinking take place. Structures and representations of this space are tied very much to the needs associated with specific activities; which attributes we visualize or illustrate should arise from the need to grasp a specific relationship or situation. If we must appreciate a topological connection, then we need not preserve all the Euclidean relationships in our representation. Thus there is a cartography for each of ego, relative and absolute space, i.e., for not only the formal geographic worlds but also the behavioral and perceptual worlds of our minds. In early education, usually the cartography of absolute space is the only one considered and utilized. As a result, children may presume that conventional and Euclidean representations are to be used rather than more cost-effective and informal ones, which in the real world are the maps of choice.

The interior of this orientation space is ill- defined. This suggests that we still know very little about human orientation. On the other hand, the magnitude of the current research, alluded to by Figure 1, suggests that our problem is one of choosing research topics which synthesize what we know rather than further dividing the various threads of our current research. It is my hope that this orientation space may help us to better understand our different perspectives on human orientation and to see across this space to others so that some useful research linkages might be established. I also suspect that the intellectual and perceptual bridges referred to in Figure 1 may provide the kinds of vehicles for developing performance activities for classrooms and articulating the kinds of linkages useful in structuring a curriculum for students wanting to discover the nature of cartography and maps and to understand the bases of their cognitive transactions with their surroundings.

EPILOGUE

At St. Paul, this paper introduced presentations by Jodie Plumert of the University of Iowa and by Herbert L. Pick Jr., Marian Heinrichs, Gina Dow and Catherine Sullivan, all of the Institute of Child Development. Plumert, in her paper which follows here, examines one relationship which may connect the facets of this orientation space– the relationship of cognitive organizational structures and their influence on the process of learning and remembering spatial relations. It is hoped that a related set of papers by other participants in the session will appear in a future issue of *Cartographic Perspectives.*

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RESUMEN

Un "espacio de orientación" es descrito brevemente como un medio de sintetizar documentación y proveer a los psicologos y cartógrafos con una base común para discutir el desarrollo cognitivo en los ninõs cuando se aplica a la educación elemental cartográfica. La documentación hace referencia al trabajo en varios campos, como por ejemplo; cómo navegan y se orientan los ninos?, cómo visualizan y, organizan el, espacio y, las relaciones espaciales?, y cómo expresan éstas ideas graficamente. ❑