Spatial Cognition of Pre-Service Teachers

Melinda Schoenfeldt

This study is concerned with examining the spatial abilities of pre-service teachers through the analysis of sketch maps. A series of t-tests and a single factor ANOVA analysis were chosen to identify differences between the means in the dependent variable, spatial ability, compared to the independent variables of gender, number of geography course taken, area of study concentration, and self-assessment of one's sense-of-direction. Data suggest that both gender ($p<0.05$) and self-assessment of one's sense-of-direction ($p<0.10$) explain significant amounts of the variance in scores on the test of spatial ability.

Keywords: *spatial cognition, pre-service teachers, sketch maps*

INTRODUCTION

Geography has been part of American education since the 17th century (Stoltman 1992). Thomas Jefferson, among other early influential Americans, believed geography to be an important subject for a primary education. In fact, geography textbooks were some of the earliest to appear in American classrooms (Smith 1997). By the 19th century, geography education was mandated in several states. However, in the early 20th century, geography instruction became less important in the American curriculum (Stoltman 1992). From the 1960s through the 1980s, geography was considered a marginal discipline in the United States. By the late 1980s, Americans' ignorance of geography became widespread knowledge (Murphy 1998). Research by Downs and Liben (1987) and others has shown that children and adults are spatially illiterate; from orienting oneself in the environment and finding one's way from place A to place B, to using maps to discover location, estimate distances, and to plan routes.

In recent years, however, there has been considerable attention given to once again include geography in schools. As a result of this attention, more elementary and secondary schools now require courses in geography, and the College Board is adding the subject to its Advanced Placement program (Murphy 1998). Geography is now identified as a core subject for American schools, on par with science and mathematics (Rediscovering Geography Committee 1997).

Significance in Pre-service Education

With attention focused on the importance of including and improving geography instruction in American schools, most resources have been used for staff development of in-service teachers. This effort has not been matched by efforts to improve opportunities for pre-service teachers to learn geography and how to teach it (Bednarz and Bednarz 1995). A recent assessment by the Council of Chief State School Officers found that only five states require geography for certification of elementary teachers (K-5) and only two-thirds require that persons intending to teach social studies have even one course in geography. "Students now enrolled in teacher education programs are not receiving adequate instruction to carry out the increased emphasis on geography in the nation's schools" (National Council for Geographic Education 1992, 5).

The pre-service teachers of today will be charged with the responsibility of teaching geographic concepts in the future, including spatial skills used in visualizing, reading, and making maps. The spatial ability of pre-service teachers may be foundational to the teaching of geographic concepts to their future students. Boehm and Sharma (1994) assert that teachers cannot teach what they themselves do not know. Shaha (1982) concluded that there is a need for "investigating the cognitive processes which underlie spatial abilities" (130). Are pre-service teachers' spatial abilities adequate to help their future students understand the spatial nature of their world? This study was undertaken to examine the spatial ability of a sample of elementary/middle school pre-service teachers by examining how pre-service teachers transfer mental maps into sketch maps in order to see if there are predictor variables that point to strong spatial ability.

From Memorizing to Thinking

To most Americans, geography is about place names. Concerns about geographic ignorance usually focus on people's inability to locate places on a world map. Geographic instruction is often equated with teaching about remote locations. But, geography should be thought of as a means rather than as an end (Rediscovering Geography Committee 1997). Geography is concerned with understanding the spatial dimension of human experience (Geography Education Standards Project 1994). Students need to be able to use geography to solve problems and to understand the spatial nature of the discipline and its impact on our lives (Petry 1995). Geographic literacy involves the use of maps to assist in the analysis of information. According to Stoltman (1992, 17),

Map skills have long been recognized to include tasks similar to those developed by Jean Piaget in his research on spatial development. Piaget's theory of spatial development presented the idea that as children mature, they change their views of how items in a landscape are related to each other. Map skills require students to think spatially and recognize different perspectives as they use maps for manipulating, comparing, and contrasting spatial information.

THEORETICAL FRAMEWORK: PSYCHOLOGY AND GEOGRAPHY COMBINE FACTORS

At the turn of the 20th century, social studies disciplines, including psychology, sociology, and anthropology, were established on university campuses. In trying to gain the stature enjoyed by the "pure" sciences, social sciences began researching the human mind. The research centered on topics that included problem solving, the nature of consciousness, and perception. The scientific method used by most of these researchers was introspection; self-reflection of the researcher's own thought patterns (Gardner 1985).

From the 1920's through the 1940s, behavioral psychology was popular. Behaviorism is based on the belief that forces in the environment that are beyond human control determine behavior. Behaviorism attempted to study human learning using techniques employed in studies of animal behavior (Gardner 1985). Behaviorism is sometimes called an "empty organism" theory of behavior. Behaviorists view the world in terms of stimuli and responses to those stimuli without acknowledging what happens in a person's mind (McNergney and Herbert 1995).

By the mid 1950s, cognitive psychology, or cognitive science as some called it, began to influence the research of social scientists (Gardner 1985). Human cognition studies look at ways in which people process information mentally. This is very much a reaction to stimulus-response theory. "Where stimulus-response theorists were interested primarily in the antecedents and consequent of intelligent behavior, information-processing psychologists are interested primarily in the mental phenomena that intervene between stimulus and response" (Sternberg and Salter 1982, 3).

"No one affected developmental psychology more than Jean Piaget" (Beilin 1992, 191). Piaget (1977) conducted many research studies involving spatial cognition. He identified stages of development: sensory-motor, preoperational, concrete operational, and formal operational. He assigned age ranges to each stage to explain that though he believed all children pass through the stages sequentially, they may do so at different ages. Piaget (Piaget

and Inhelder 1956) assigned the ability to understand representational forms of spatial organization (map reading) to children over eight years of age.

Geography is recognized as the spatial science concerned with the location of elements on the earth's surface and their relationship to each other (Stoltman 1991). Cognitive representation is the way individuals mentally represent information about their environment. Human cognitive representations of space have been studied in geography for more than 25 years (Rediscovering Geography Committee 1997). As Downs and Meyer (1978) note, "cognitive mapping studies find affinity with and inspiration from psychology" (68).

Psychologists David Stea, Terence Lee, and Stephen Kaplan teamed with geographers in an attempt to understand the mental processes involved in cognitive representations of the spatial environment. Downs and Meyers (1978, 73) point out,

> The ties between psychology and geography strongly influenced the direction of collaborative effort. Psychology brought a sense of cognitive process, geography a sense of environment, and the concern switched from an emphasis on static, visual images and maps to an exploration of the processes of learning and manipulating information about the spatial environment.

Storage of Spatial Cognitive Information

Researchers have identified two basic types of spatial cognitive storage: imagery (analog) and propositions (Evans 1980; Miller and Burton 1994). Imagery depicts mental images as internally coded in a spatial structure (Miller and Burton 1994). Kosslyn, Ball, and Reiser (1978) suggested that people who use such coding are able to scan mental images of a map as if they were looking at an external map. Propositional recall suggests that mental images be encoded in terms of linear orderings that sequence the items. People who use this type of coding create mental maps that represent paths between familiar locations. Both forms of storage schema for cognitive maps, analog or propositional, (Evans 1980; Weitzman 1981) can be externally represented through the use of sketch maps.

Tests Used to Measure Spatial Ability

Many methods have been used to measure spatial ability (Kearney and Kaplan 1997). Semantic proximity (word association) tasks, open-ended

interviews, and free-card sorting techniques have used verbal recall of spatial information. The assumption of using such tests was that people acquire and store information about their surroundings in some schematized form (Rovine and Weisman 1989).

There are problems, however, assuming that linguistic structure is representative of cognitive structure of spatial data (Kearney and Kaplan 1997). Other types of tests used to assess spatial ability include paper folding, mental image rotation tests (MIR), and block counting (Turner 1983). These tests were designed to look for isolated spatial abilities such as rotating perspective or understanding three-dimensional models. Researchers in cognitive studies have largely depended on an individual's hand-drawn sketch map as a way to externalize the individual's mental map of the environment.

Evans (1980) cites three possible shortcomings of using sketch maps. One concern was that poor drawing ability might underrepresent a person's knowledge. There was a substantial correlation (0.62) between ratings of children's accuracy on sketch maps and their scores on the Goodenough-Harris Draw-A-Man-Test (Evans 1980). However, Rothwell's (1976) adult data indicate that artistic ability may have only slight effect on sketch maps. While sketch maps may not be appropriate for use with young children, the subjects in this study were adults.

A second of Evan's (1980) concerns in using sketch maps is that they may test a subject's free-recall ability rather than recall of one's cognitive map. Bannerjee (1971) and Milgram and Jodelet (1976) found that accurate picture recognition was slightly greater than free-recall for accuracy in drawing sketch maps. The current study used picture cues of the buildings on campus for the subjects rather than reliance on their free recall.

A third concern reported by Evans (1980) is that first-drawn elements of sketch maps may have substantial effects on the relative position of subsequently drawn elements. The current study showed subjects the visual cues twice and they were instructed to make changes to their drawings at any time.

Golledge (1976) lists sketch maps as one of four methods for "extracting" cognitive information. Rovine and Weisman (1989) report that sketch maps were the most commonly used techniques in early cognitive mapping research and argue for their continued use. They cite research by Rothwell (1976) that suggested that sketch maps are reliable and valid in research with adults. Data gathered in environmental cognition studies by Lynch (1960) came primarily from hand-drawn sketch maps. After controlling for Evans' three concerns, and following the lead of respected researchers, the use of sketch maps seemed justified on a logical and empirical basis and became the research focus for the present study.

STUDY DESIGN

Research Hypotheses

H_o: There is no difference between the means of the dependent variable, spatial ability score, when compared with the independent variables of gender, number of geography courses taken, self-assessment of one's sense of direction, or area of content concentration in elementary level pre-service teachers.

Methodology

Subjects were asked to self-assess their spatial ability by classifying their sense of direction as good or poor before producing a sketch map. Subjects were also asked to identify their gender, number of geography courses taken, and their content subject area of concentration. Each study subject was then given a blank 8 x 11-inch piece of paper. Boundary roads were verbally identified for the subjects. The subjects were then asked to draw in the boundaries and to identify north on their map. When given visual stimuli (color slides of thirteen familiar buildings on campus), subjects were asked to map the locations of the buildings. They were allowed to make changes at any point, especially after seeing all thirteen buildings. Golledge (1976) reported that individuals establish the position of places with respect to each other and with respect to cardinal directions. A series of t-tests and a single factor analysis of variance (ANOVA) were used to analyze the influence exerted by four independent variables on the dependent variable of spatial ability. The four independent variables were gender, subject content area concentration of study, self-report of one's sense of direction, and number of formal geography classes taken.

Demographics

The subjects for this study were four intact groups (N=73) of students enrolled at a Midwestern university in an elementary/middle level education program that is accredited by the National Council for Accreditation of Teacher Education (NCATE). The university is a land grand institution with a strong research orientation and a total enrollment of approximately 20,000 students. The College of Education graduates approximately 400 students each year. The subjects of this study were predominantly of Anglo ethnicity, and a minority of the sample subjects was Hispanic and African-Americans. There were eleven male and sixty-two female subjects. The small number of males

reflects the smaller number of males enrolled in the elementary education program. All subjects have a cumulative GPA of 2.75 or higher. The study was conducted using all available pre-service teachers in four sections of the Elementary/Middle Level Social Studies Methods course. All students were in their last semester of study before student teaching.

Data Collection

The individual sketch maps were scored on a scale from zero to twenty-six, and the maps were categorized as either representative of an analog or propositional cognitive recall. In this study, buildings placed in the correct quadrant of the campus received one point. Buildings placed in correct relative location (due south, northeast) to the next nearest-pictured building received another point. A perfect score was twenty-six. The mean score on the dependent variable was compared with respective mean scores for each of the independent variables. Maps drawn using linear, pathlike drawings were labeled propositional, while maps that used a "scanning the environment" technique were labeled analog. For example, subjects who drew a gridwork of streets as a way of locating landmarks were considered to be using analog recall. The maps were scored and categorized by two different raters. The inter-rater reliability was 0.97.

The independent variables represent categorical data. Self-report of one's sense of direction was categorized as good or poor. Number of geography courses taken were divided into three categories; 1) one course represents minimal exposure, 2) two courses taken represents a step beyond minimal exposure, and 3) three or more courses taken represents maximum exposure. There is no zero category since all education students at this university are required to take at least one geography course. Research reports (Rothwell 1976; Stoltman 1992; Bednarz and Bednarz 1995; Casey 1996) have made the case that math, geography, art, and science require spatial ability. Those content specialties were categorized as high spatial subjects. Other areas of content concentration were categorized as low spatial subjects. Subjects who listed social studies as an area of concentration were put in the high spatial category since geography is subsumed under the more general category called social studies.

ANALYSIS OF DATA

The null hypothesis stated there would be no difference in the mean test score between spatial ability and the mean values for the independent variables of gender, self-assessment, area of concentration, or number of geography

courses. Analysis included submitting the data to *t*- tests and a one-way ANOVA to test the mean values for differences at the 0.10 or less significance level. The significance level for accepting and rejecting the hypotheses was set at the 0.10 level due to the nature of the spatial ability test and the independent variables. That level of significance was determined to introduce adequate rigor to the data analysis procedures.

The mean scores for the sketch map drawing criteria compared to gender (Table 1) suggest that males tend to score higher than females in sketch map drawing. The statistics in Table 2 indicate that a difference this large or larger can be expected only about three percent of the time. This is a statistically significant difference and so the null hypothesis for the case of gender is rejected. There is a significant difference between the sketch map drawing of male and female students, and it is slightly in favor of males. Data suggests a significant effect ($p < 0.05$) of gender on spatial ability score.

Area of concentration was represented by two categories, high spatial and low spatial. Data in Table 1 shows that subjects enrolled in low spatial areas of concentration scored slightly higher than subjects enrolled in high spatial areas of concentration. But Levene's Test for Equality of Variance in Table 2 shows no statistically significant difference between the two groups. The null hypothesis is accepted for the independent variable of study of concentration.

A third independent variable of this study was self-assessment of one's sense of direction. Subjects identified themselves as either good or poor. The data in Table 1 show that those who identified themselves as having a good sense of direction outscored those who identified themselves as having a poor sense of direction by almost two points. Levene's Test for Equality of Variances suggest there is a significant statistical difference ($p < 0.10$) between the two groups' sense of direction. Therefore, the null hypothesis for self-assessment of one's sense of direction is rejected. The data suggest self-assessment of one's ability is an important element in spatial ability.

The null hypothesis was proposed regarding differences in the mean values for spatial ability scores compared to the number of college geography courses taken. Data are shown in Table 3. The *p* value (0.4149) is greater than the alpha level (0.05) and the null hypothesis is accepted. Data suggest there is no significant difference in spatial ability mean scores between groups of students based on geography courses completed.

Perhaps as interesting as the mean score differences by gender are the scores themselves. The overall mean score of twenty-one, which is approximately eighty-one percent of a perfect score, suggests that many of the preservice teachers were able to complete the sketch map of campus, a familiar environment, with proficiency. However, scores of five and eight were recorded suggesting a wide range of ability relative to the task.

Closely related to individual score was whether more pre-service teachers used analog or propositional recall strategy when drawing the sketch map. Maps of twenty-four subjects, thirty-three percent of the total sample, were classified as using analog recall. Table 4 shows the type of map drawn by gender. Males in the sample tended to use analog recall while females tended to use propositional recall strategies. Six maps were scored with a perfect twenty-six. All six demonstrated analog recall strategies.

Arguably, the most interesting sketch map was map number nine (Figure 1). This particular map received a score of five, the lowest score in the sample and can almost be thought of as a *mirror map*. The northern and southern boundary roads are correct. The eastern and western boundary roads are reversed, as are the thirteen campus landmarks and buildings. When held up to a mirror, the buildings are in remarkably accurate relative location to one another and placed in the proper quadrants. It would be interesting to have that subject repeat a sketch map task to determine if the practice is consistent. The confidentiality of subjects assured by the research design made it impossible to identify the individual.

Figure 2, map number fifty-eight, received a perfect score from both raters. It was also classified as analog by both raters. The subject added internal roads as a grid system to aid in more accurate placement of the campus buildings and landmarks. Another interesting element of map fifty-eight is that the subject accurately drew the roads, including curves. Evans (1980) reported that the more commonly noted distortions of sketch maps are the straightening of long, gradual curves, the squaring of non-perpendicular intersections, and the aligning of non-parallel streets. Those distortions existed on most of the maps. Note in particular (Figure 2) that the northern boundary road, called Claflin Road, curves sharply. Eight subjects drew the road with a curve and half of those curved the road in the wrong direction.

Figure 3, map number eighteen, shows an example of a map that was classified as propositional by the two raters. Two internal campus roads are added, but they appear to be used as paths to certain buildings or areas of campus. They do not seem to be added to establish a grid system. The addition of the roads did not help the subject to place landmarks more accurately.

SUMMARY

Males from the sample population outscored females. These findings appear to coincide with study results from Halpern (1992), Law, Pelligrino, and Hunt (1993), and others who have reported that males outperform females on spatial tasks. Though males' mean scores were higher than the

Factor of Interest	n	Mean	SD
Gender			
Male	11	23.82	2.48
Female	62	20.70	4.47
Area of Concentration			
High Spatial	31	21.03	4.45
Low Spatial	42	21.29	4.34
Self-Assessment			
Good	52	21.73	4.08
Poor	20	19.85	4.93
Number of Geography Courses			
One	34	20.76	4.67
Two	30	21.97	3.23
Three +	6	20.00	6.42

Table 1. Means and standard deviations by sample categories. Mean scores shown for each independent variable (sample N=73).

mean scores for females, it should be noted that the six perfect scores of twenty-six were evenly divided between the genders.

Subjects who identified themselves as having a good sense of direction outscored subjects who identified themselves as having a poor sense of direction. Ninety-one percent of the males identified themselves as having a good sense of direction, while only about sixty-six percent of the females did so. These findings seem to confirm Lunneborg's (1982) study that concluded that university-aged males tend to self-assess themselves higher than do females on performance-based activities. It seems that males have higher self-esteem on spatial tasks. But the data from this study do show that the males had higher scores and that the subjects, both male and female, were seemingly able to identify their spatial strengths with some degree of accuracy.

The study's data do not show a statistically significant relationship between number of geography courses taken and a high score on the sketch

Factor	Assumption of Variance	Test Statistic	Standard Error	P-Value
Gender				
	equal	2.24	1.388	0.028
	unequal	3.31	0.939	0.003
	Levene's Test: F=0.007	p=0.132		
Areas of Concentration				
	equal	-0.24	1.039	0.808
	unequal	-0.24	1.043	0.809
	Levene's Test: F=0.007	p=0.934		
Self-Assessment				
	equal	1.65	1.139	0.103
	unequal	1.52	1.240	0.140
	Levene's Test: F=1.254	p=0.267		

Table 2. Comparison of factor levels by sample categories.

map task. Eighty-eight percent of the subjects had taken one or two geography courses. Forty-seven percent had taken only one. Since a relatively small percentage, eight percent, had taken three or more courses, it was not possible to develop scores across a wide range for geography courses completed. Furthermore, it was not known what types of geography courses had been taken, and whether certain types of courses had greater effects on spatial skills than did others.

Number of Geography Courses					
Source	D.F.	Sum of Mean Squares	F Squares	F Ratio	Prob.
Between Groups	2	32.70	16.35	0.8913	0.4149
Within Groups	67	1229.08	18.34		
Total	69	1261.78			

Group	n	Mean	SD	SE 95%	Conf Int. for Mean
1 Course	34	20.7647	4.6710	0.8011	19.1348 to 22.3946
2 Courses	30	21.9667	3.2322	0.5901	20.7597 to 23.1736
3+ Courses	6	20.0000	6.4187	0.6204	13.2671 to 26.7359

Table 3. One-way analysis of variance on the effect of number of geography courses taken on sketch map scores.

Gender		Type of Map Analog	Propositional	Row Total
Male	n	7	4	11
	%	63.6	36.4	15.1
Female	n	17	45	62
	%	27.4	72.6	84.9
Column	n	24	49	73
	%	32.9	67.1	100

Table 4. Analog and propositional spatial skills usage compared by gender. More preservice (67%) teachers used a path-like (propositional) cognitive recall strategy. A larger percentage of males (63.6%) than females (27.4%) used a grid-like (analog) recall strategy.

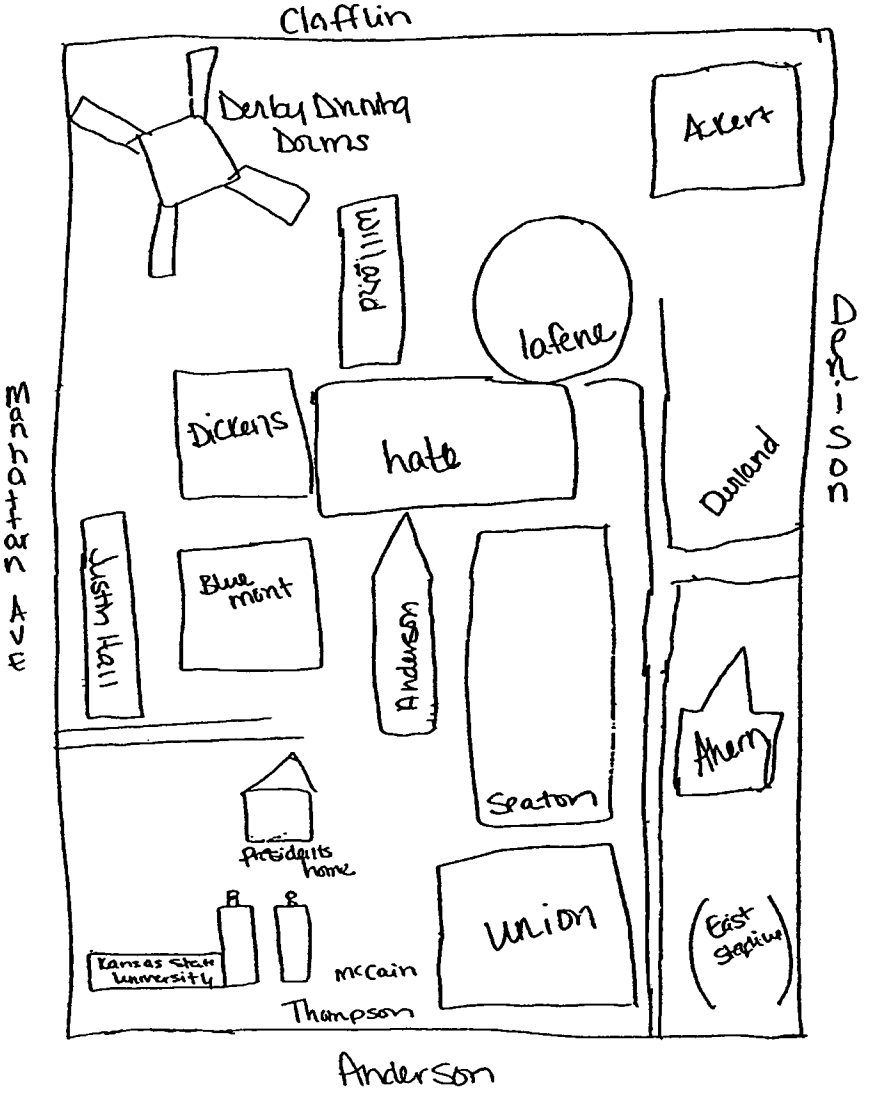

Figure 1. A "mirror map." Northern and southern boundaries are correctly placed. All other information is reversed. Drawn by a female subject.

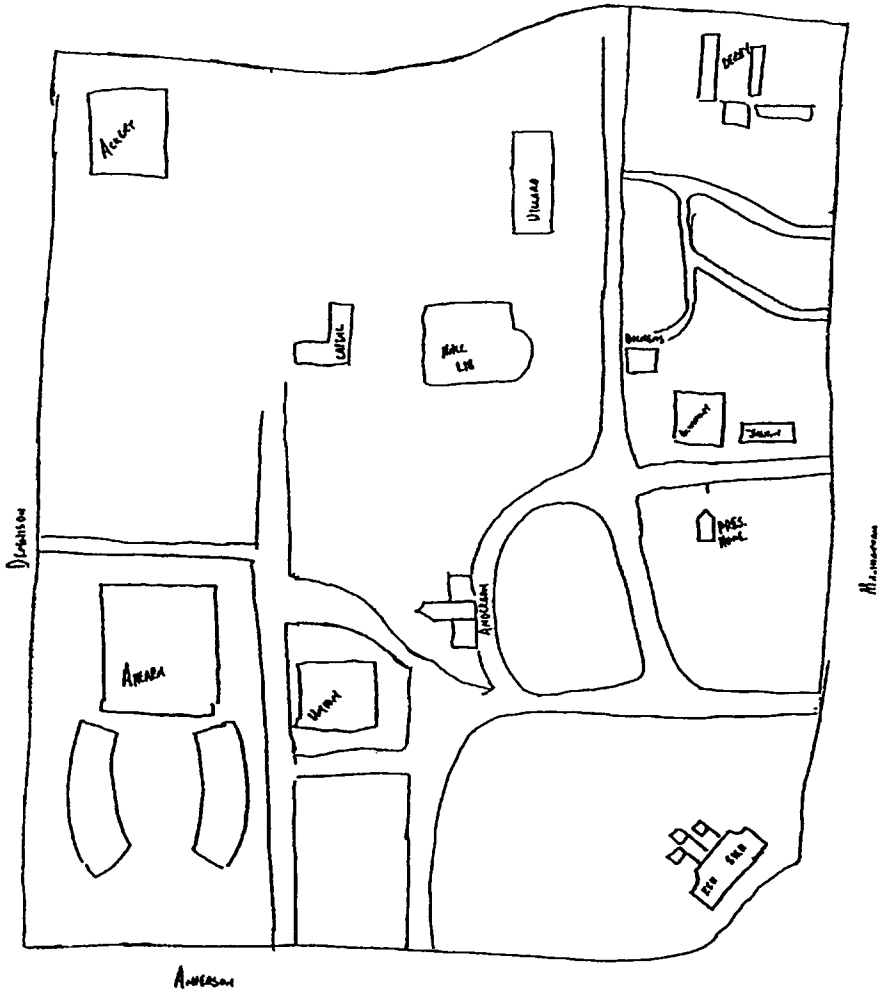

Figure 2. Map fifty-eight. A map that received a perfect score of twenty-six. Identified as representing a grid-like, or analog, cognitive recall strategy. Drawn by a male subject.

DISCUSSION AND RECOMMENDATIONS

It is important to remember that students now enrolled in pre-service education programs attended elementary, middle, and high school during years that geography instruction was de-emphasized or missing altogether. University geography courses may have been the students' first encounters with geography. Depending on what geography courses are taken, it is likely that pre-service teachers may not receive much experience with spatial concepts. In retrospect, it was not surprising to find that the number of geography courses taken by the subjects of this study did not have a statistically significant influence on their sketch map test scores. It would seem important to determine through research which geography courses most influence spatial skills development.

Future research could focus on variables dependent upon instructional method and gender. Research suggesting that males and females learn spatial skills differently would be helpful in designing appropriate geography-based spatial learning opportunities for pre-service teachers.

The findings of this study indicate a wide range of spatial ability for elementary pre-service teachers. A core, required geography course that emphasizes the development and refinement of spatial skills seems to be an important part of teacher education programs. Learning the importance of and how to purposefully integrate spatial clues of environments within a course appears to be meaningful. Purposeful input may be illustrated by thinking of a driver and passenger passing through unfamiliar territory. The driver of the car is more likely aware of buildings, landmarks, and routes, as well as his own relation to those sights, than is a passenger. The driver has the task of navigating and so pays keen attention to the environment, while the passenger may only make note of special landmarks or attention-grabbing landscapes. Research is needed to determine if spatially unskilled subjects significantly improve their performance on spatial tasks after receiving purposeful input.

The pre-service teachers would also benefit from tying geography skills to current learning theory. A study of cognitive theory within their pedagogy classes would be appropriate to help the pre-service teachers begin to think about how their future students encode and retrieve spatial data. Liben (1981) speaks of spatial storage, spatial thought, and spatial products. Including those ideas into a higher education pedagogy course would perhaps help pre-service students connect geography and psychology.

At the very least, pre-service teachers need to have a working knowledge of the National Geography Standards (Geography Education Standards Project 1994). Pre-service teachers must be taught from the standards and be taught how to use the standards in lesson design. In so doing, they become

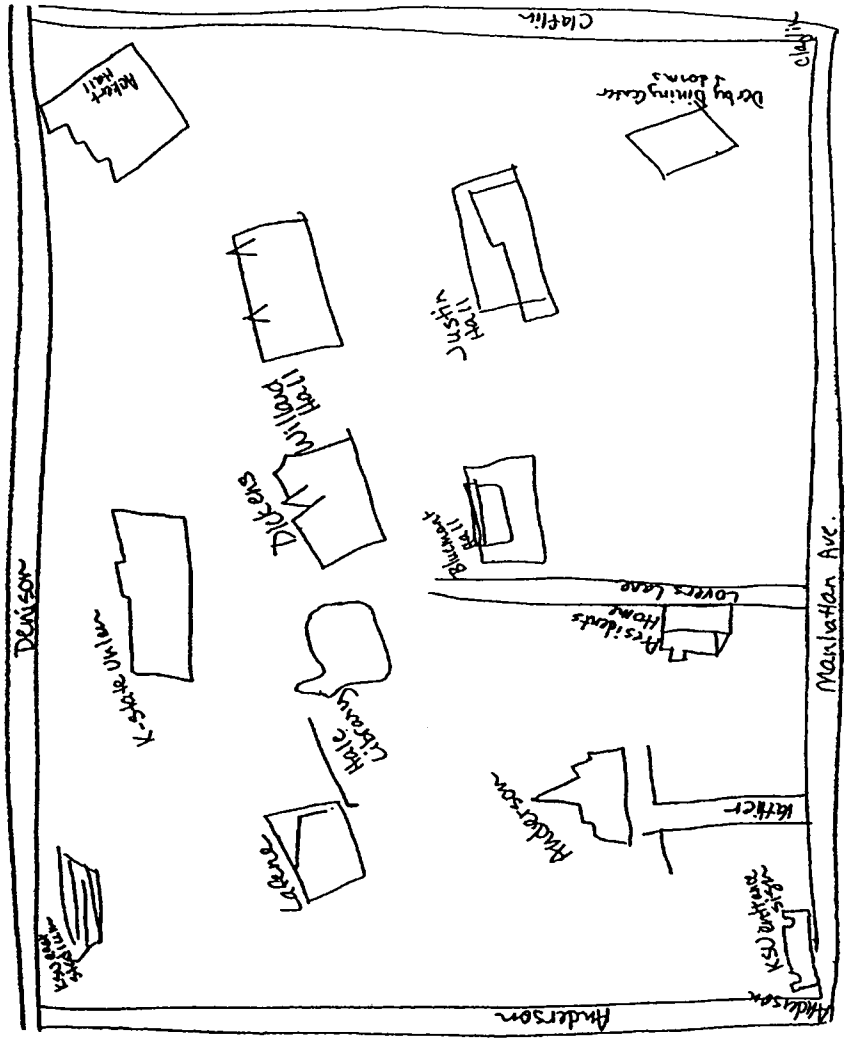

Figure 3. A map identified as representative of a path-like or propositional cognitive recall strategy. Drawn by a female subject.

more geographically proficient and ready to apply their geographic knowledge in elementary classrooms.

REFERENCES

Banerjee, T.K. 1971. *A Study in Environmental Perception and Learning.* Unpublished doctoral dissertation. Cambridge, Massachusetts: Massachusetts Institute of Technology.

Bednarz, S., and Bednarz, R.S. 1995. Pre-service geography education. *Journal of Geography* 94(5):482-486.

Beilin, H. 1992. Piaget's enduring contribution to developmental psychology. *Developmental Psychology* 28(2):191-204.

Boehm, R., Brierly, J., and Sharma, M. 1994. The bete noir of geographic education: Teacher training programs. *Journal of Geography* 93(2):21-25.

Casey, M.B. 1996. Understanding individual differences in spatial ability within females: A nature/nurture interactionist framework. *Developmental Review* 16(3):241-260.

Downs, R.M., and Liben, L.S. 1987. Children's understanding of maps. In *Cognitive Process and Spatial Orientation in Animal and Man,* eds., P. Ellen & C. Thinius-Blanc, pp. 202-219. Boston, Massachusetts: Martinus/Nithoff.

Downs, R.M., and Meyer, J.T. 1978. Geography and the mind. *American Behavioral Scientist* 22(1):59-77.

Evans, G. 1980. Environmental cognition. *Psychological Bulletin* 88(2):259-287.

Gardner, H. 1985. *The Mind's New Science: A History of the Cognitive Revolution.* New York: Basic Books, Inc.

Geography Education Standards Project. 1994. *Geography for Life: National Geography Standards.* Washington, D.C.: National Geographic Society.

Golledge, R.G. 1976. Methods and methodological issues in environmental cognition research. In *Environmental Knowing,* eds. G.T. Moore, and R.G. Golledge, pp. 4-47. Stroudsburg, Pennsylvania: Dowden, Hutchinson, and Ross.

Halpern, D. 1992. *Sex Differences in Cognitive Abilities (2nd ed.).* Hillsdale, New Jersey: Erlbaum.

Hermann, D. 1995. Overcoming geographic innocence in geography education. *Journal of Geography* 94(5):527-529.

Kearney, A.R., and Kaplan, S. 1997. Toward a methodology for the measurement of knowledge structures of ordinary people: The conceptual content cognitive map. *Environment and Behavior* 29(5):579-617.

Kosslyn, S.M., Ball, T.M., and Reiser, B.J. 1978. Visual images preserve metric spatial information: Evidence from studies of image scanning. *Journal of Experimental Psychology: Human Perception and Performance* 4(1):47-60.

Law, D.J. , Pellegrino, J.W., and Hunt, E.B. 1993. Comparing the tortoise and the hare: Gender differences and experience in dynamic spatial reasoning tasks. *Psychological Science* 4(1):35-40.

Liben, L.S. 1981. Spatial representation and behavior: Multiple perspectives. In *Spatial Representation and Behavior Across the Life Span,* eds., L.S. Liben, A.H. Patterson, and N. Necombe, New York: Academic Press.

Lunneborg, P.W. 1982. Sex differences in self-assessed, everyday spatial abilities. *Perceptual and Motor Skills* 55(3):200-202.

Lynch, K. 1960. *The Image of the City.* Cambridge, Massachusetts: MIT Press.

McNergney, R.F., and Herbert, J.M. 1995. *Foundations of Education: The Challenge of Professional Practice.* Boston, Massachusetts: Allyn and Bacon.

Milgram, S., and Jodelet, D. 1976. Psychological maps of Paris. In *Environmental Psychology (2nd ed.),* eds., H. Proshansky, W. Ittelson, and L. Rivlin, pp. 115-121. New York: Holt, Rinehart & Winston.

Miller, H.B., and Burton, J.K. 1994. Images and imagery theory. In *Visual Literacy: A Spectrum of Visual Learning*, eds., D.M. Moore & F.M. Dwyer, pp. 65-83. Englewood Cliffs, California: Educational Technology Publications.

Murphy, A.B. 1998. Rediscovering the importance of geography. *The Chronicle of Higher Education* 45(10):64.

National Council for Geographic Education. 1992. The role of geography in pre-service teacher preparation: Geography in the social studies. *Journal of Geography* 91(5), Suppl. 2.

Petry, A.K. 1995. Future teachers of geography: Whose opportunity? *Journal of Geography* 94(5):487-494.

Piaget, J. 1977. *The Development of Thought: Equilibration of Cognitive Structures.* New York: The Viking Press.

Piaget, J., and Inhelder, B. 1956. *The Child's Conception of Space.* London, England: Routledge and Kegan Paul.

Rediscovering Geography Committee. 1997. *Rediscovering Geography.* Washington, D.C.: National Academy Press.

Rothwell, D. 1976. Cognitive mapping of the home environment. In *The Behavioral Basis of Design*, eds., P. Suedfeld & J. Russell, pp. 97-123. Stroudsburg, Pennsylvania: Dowden, Hutchinson & Ross.

Rovine, M., & Weisman, G.D. 1989. Sketch-map variables as predictors of way-finding performance. *Journal of Environmental Psychology* 9(2):217-232.

Shaha, S.H. 1982. *Cognitive Processes Functional in Spatial Recall. Report No. CSE-R-193.* Washington, D.C.: Institute of Education. (ERIC Document Reproduction Service No. ED 228 271).

Smith, B.A. 1997. *Social Studies Teacher's Companion.* Boston, Massachusetts: Houghton Mifflin.

Sternberg, R.J., & Salter, W. 1982. Conceptions of intelligence. In *Handbook of Human Intelligence*, ed., R.J. Sternberg, pp. 3-28. New York: Cambridge University Press.

Stoltman, J.P. 1991. Research on geography teaching. In *Handbook of Research on Social Studies and Learning: A Project of NCSS*, ed., J. P. Shaver, pp. 437-446. New York: Macmillan.

_____ 1992. *Teaching Map and Globe Skills, K-6.* Skokie, Illinois: Rand McNally Co.

Turner, D.R. 1983. *Practice for officer candidate tests.* New York: Arco Publishing.

Weitzman, D.O. 1981. *Individual differences in spatial memory: Thinking backwards.* Paper presented at the 22nd annual meeting of the Psychonomic Society, Philadelphia, Pennsylvania.

Melinda Shoenfeldt *taught in public and private elementary, middle, and high schools for eighteen years before she received her Ph.D. from Kansas State University. Her Ph.D. is in curriculum and instruction with an emphasis in social studies education. She is very concerned about the quality of pre-service teacher education programs and the competencies of the teachers those programs produce, especially in the area of social studies and, more specifically, in geography education. She is currently assistant professor in the elementary education department at Ball State University in Muncie, Indiana.*