Exploring geographic knowledge through mapping

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Abstract: Knowledge about the world is expressed in many ways. Sketch mapping has been a dominant method used by researchers in a variety of disciplines to indicate both spatial and geographic knowledge. Unfortunately, sketch mapping tasks have the potential to be confounded by drawing ability and non-spatial recall ability, among other variables. By using three types of sketch mapping tasks, student knowledge of world geography was assessed. Knowledge of world geography was assessed by the rate of accurate inclusion of individual countries. Comparing student map production to their individual performance on two spatial figures drawing tasks (the complex figures test) allowed for a comparison of geographic knowledge and both drawing and visuo-spatial ability. Students in two geography classes participated, one a first year cultural geography class the other a senior technical geography class. Results indicate that drawing ability can be controlled for in sketch mapping tasks and that the relationships among geographic knowledge, spatial ability, and drawing skill can be understood, and that this understanding can be used to increase the validity of sketch mapping tasks.

Introduction

In late November 2002 geographic knowledge and literacy became a front page item across both Canada and the United States. The National Geographic Society (NGS) presented the results of the National Geographic-Roper 2002 Global Geographic Literacy survey. The survey showed that globally geographic knowledge is surprisingly poor and that such knowledge is particularly low in North America (Canada, the USA, and Mexico). While the headlines focused on the dramatic lack of knowledge among survey participants, there were several positive outcomes. Over the past several years the numbers of students in North

America exposed to geographic curriculum in their formal education increased (as did geographic literacy, although not as much as many had hoped it would).

The NGS survey illustrated two relevant issues related to the current study. The relative impact of, and relationship between, geographic instruction and geographic knowledge must be better understood and the methodology for evaluating geographic literacy and knowledge must be evaluated. A traditional method for evaluating geographic knowledge of the world is by having people (participants) complete a sketch mapping exercise (Blades 1990, Pinheiro 1998, Taketa 1996, Saarinen 1999). Sketch mapping methodologies have proven reliable (Blades 1990), have produced a better understanding of how people around the world understand global geography (Saarinen 1999, Stea, Elguea and Blaut 1997, Stea, Blaut and Stephens 1996, Saarinen 1973), and have been used in several educational and research based applications (Pinheiro 1998, Golledge 1985, Kitchin 1997). What has been explored less thoroughly is the extent to which the sketch mapping paradigm is evaluating the intended independent variable(s); in most cases the independent variables are related to the geographic or spatial knowledge of the individual completing the sketch map. As most sketch mapping tasks involve some component of drawing ability and spatial memory it seems reasonable to determine the extent to which these two variables play a role in the sketch mapping process.

Sketch mapping and related drawing and mapping tasks have been used in a variety of ways to examine spatial and geographic knowledge as well as provide additional evidence for spatial reasoning abilities of different types. As suggested above the most common sketch mapping task is to have participants free draw a map of the world (or some subset) labeling and drawing countries and other geographic features (Saarinen 1999, 1973). The only limitations these types of techniques present the individual producing the sketch map is the size of the paper on which the map is drawn and the specific instructions that are delivered by the researcher. In order to examine different constructs, such as how spatial information is processed during wayfinding and navigation, how scale affects knowledge representation, knowledge of different types (country capitals, physical features within larger spaces, etc.), among many others, the sketch mapping technique has been modified with reliable, and important results (Blades 1990). For all of these techniques some aspect of the mapping process is limited so the result is a task that is more likely to produce data that tests the research hypothesis (hypotheses). In most cases this approach is adopted to focus on a specific type of knowledge or to eliminate the role that drawing ability might play in the quality of sketch map produced by an individual. An individual with drawing skills may be able to produce a more well balanced drawing that better supports the inclusion of geographic features. Poor drawing ability is more likely to result in a map that does not use space in an efficient manner and will create a situation in which some feature cannot be included, labeled, or properly identified.

These types of "modified" mapping tasks can take many forms. In a task presented to blind participants in a navigation experiment, Jacobson (1998) provided individual pieces that were to be used to build a model of the space they had recently learned. As with most modified mapping tasks at least one variable in the mapping process is limited in such a way that the participants do not have complete freedom in how a map is drawn, a model built, or features labeled. There have been several mapping tasks that have not been as abstract as the Jacobson example, in which participants are provided with map elements (symbols, labels, objects, and other features) which are in turn placed on the map to indicate the correct location of each map element (Ferguson and Hegarty 1994, Tversky and Taylor 1998). Instead of providing the elements that will be added to the map, the research can also limit the space being mapped, or provide some other frame of reference within which the map will be completed. These "frames" can take the form of a traditional neat line, but can also include an arrangement of predetermined features, continental or national boundaries, or other well known geographic information. Each of the above mentioned techniques can facilitate the collection of valid and more focused data.

While a variety of sketch mapping techniques have been used to study a broad range of topics in geography and cognate disciplines there has been relatively little research examining the relationship between different sketch mapping tasks and the constructs they are intended to measure (a sketch mapping task's external validity). This research takes a systematic look at three derivations of a common sketch mapping task and compares performance (as measured by geographic knowledge communicated through the sketch mapping task) among the sketching tasks as well as to a non-geographic spatial drawing and spatial memory task. By using a task that can measure both drawing ability and spatial memory independently from geographic knowledge we can examine the extent to which drawing ability and non-geographic spatial memory play in performance on sketch mapping tasks that rely on drawing ability to varying degrees. Specifically, the object is to determine the role that drawing ability and spatial memory play in sketch map performance. The hypothesis is that drawing ability will play a role in the ability to complete a sketch mapping task that relies to some extent on the ability to draw an accurate (proportional, complete) image of the area being mapped, even if the relative accuracy of the map is not evaluated and the only measure is the number of countries labeled.

Methods

Participants:

Thirty participants from two separate geography classes took part in the study: seven participants from an upper year geography course (all female), and twenty-three participants from an introductory human geography course (seventeen females and six males). The mean age of the participants from both courses was twenty-two years. All subjects provided informed consent and completed the survey on a voluntary basis. While this sample is relatively small in comparison to other larger sketch mapping projects (Saarinen 1999) it is not out of the range of experimental behavioral projects examining spatial cognition in a controlled setting. Furthermore, the use of a repeated measures design in which within participant variation is measured the validity of a smaller sample size is increased.

Materials:

All of the survey materials were presented in one test packet per participant. A random code number was assigned to each packet. The test packet consisted of six tasks. First, there was a background questionnaire that asked the participants to identify their age, sex, birthplace, education and travel history. The background questionnaire was followed by five drawing and mapping tasks: a complex figure drawing task; a world sketch map task; two different world map labeling tasks; and finally a complex figure memory task. Also, all participants were provided with consent and debriefing forms.

Procedures:

The testing was done during class time in a mass testing format. The participants were instructed to work individually on each task, to not look forward or backward through the test packet during the test (except where indicated below, and only during the completion of an individual task), and to proceed to the next task only when instructed to do so. Each task was timed and accompanied by written and verbal instructions to ensure that the participants understood each component of the experiment. Time to complete each task was based on a pilot study completed by a small sample of students and staff.

TASK 1: Complex Figure Drawing

After completing the background questionnaire participants were instructed to begin the first task, which was a complex figure-copying task in which the participants were instructed to copy a figure drawing as accurately as possible (Figure 1). The participant's reproduction was scored based on the individual elements it included that were identical to that of the original; a perfect score is 36. This task was used as an index of drawing ability that did not include any world geography component. Participants were allowed three minutes for this task.

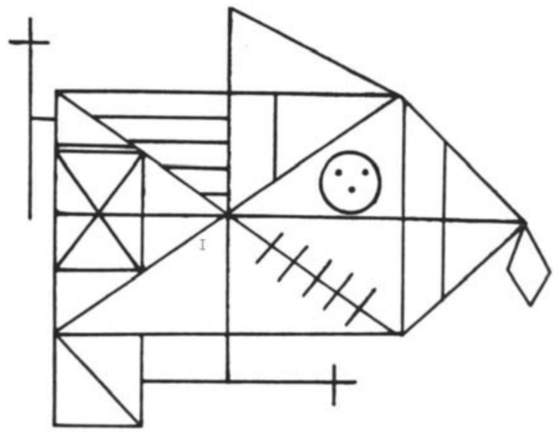

Figure 1: *Complex Figures Test used in both copying task and drawing from memory task.*

TASK 2: Free hand World Sketch Map

The second task required the subjects to draw a sketch map of the world and accurately label as many countries as possible, given the following instructions:

> "Draw a sketch map of the world. Label all the countries and any other features you think are of interest. Do not worry if your map is not perfect. Just do the best you can. We are sure you will find this an interesting experience once you get started." (Saarinen 1999)

This task was completed on a blank 8 ½ by 11-inch sheet of paper. The intent of this task was to measure participants' knowledge of world geography (as indicated by the number of countries correctly labeled). The only dependent measure for this task is the number of country names placed on the map associated with a drawn area. There was no evaluation of whether countries or any other subset of the world (physical or social) were accurately drawn, as this would be difficult to determine given the range of drawing ability that is usually expressed on sketch maps. Likewise any list of country names was ignored when maps were being scored. This task allows for a comparison of other sketch map techniques that rely less on drawing ability and more on knowledge of the countries of the world, to a task that relies on drawing ability. If one cannot draw a well proportioned map that includes space for all of the (known) countries, then it will difficult to label all of those known countries. Participants were given twelve minutes to complete this task.

TASK 3: World Map Labeling

Participants were then given a map labeling task. This task consisted of three regional outline maps covering the entire world and included the outlines of 193 countries, the maps were: 1. The Americas; 2. Europe and Africa; 3. Asia. Participants were instructed to accurately label as many countries on the maps as possible. Participants were allowed to label countries in any order and were, therefore, allowed to move back and forth among the three maps. The intent of this task was to measure participants' knowledge of world geography (as indicated by the number of countries correctly labeled) in a setting that does not rely on drawing ability. For this task participant scores were based on the number of countries that were accurately labeled, country names did not have to be placed within or completely within the boundaries of that country but there did need to be a clear association between the country label and that country's outline on the appropriate map. This task allowed for the measurement of participants' memory for and knowledge of world countries and their locations independent of drawing ability. Participants were allowed ten minutes for this task.

TASK 4: World Map Labeling with Country List

The final mapping task was a modified map labeling exercise. Participants were provided an unlabeled outline map of the world (single sheet, same countries as the maps in task three) and a separate list of countries numbered in alphabetical order. The participants were asked to indicate, as accurately as possible, the locations of countries by writing the number corresponding to each country (from the alphabetical list) in the correct location on the map. As a modification of the preceding labeling task, the intent of this task was to eliminate the participants' need to remember the names of countries for which they might have geographic (locational) knowledge. This task was scored based on the total number of countries accurately labeled (numbers are clearly associated with the correct country outline). This task allowed for the measurement of participants' knowledge of world countries and their locations and was independent of drawing ability. The participants were given twelve minutes for this task.

TASK 5: Complex Figure from Memory

For the final task participants drew the complex figure (from task #1) from memory on a blank sheet of paper. Drawings were scored in the same manner as the copying task and were used to measure spatial memory and as a second drawing ability index. They were given five minutes to complete this task.

The total time to complete the entire test packet was forty-two minutes. At the end of the experiment any further questions were answered and participants were given debriefing forms upon completion of the test packet.

Results

Preliminary Results:

One participant was eliminated as an outlier (more than three standard deviations from the mean of number of countries recalled on all three map tasks). Preliminary analysis of participant performance indicates that geographic knowledge was easier to express in the two labeling tasks (labeling and labeling with country list) than in the free sketch map task. The mean number of countries labeled on the free sketch map was 19 (total number of countries labeled, with no evaluation of whether labels were attached to correct countries), while on the labeling and labeling from country list means were 26 and 25 countries accurately labeled (labels attached to correct country outlines), respectively. For the entire participant pool, collapsing across sex, geography courses taken, and course in which participants were enrolled at the time of testing, the difference between the free sketch task and the map labeling from memory task was significant, while the difference between the free sketch task and the map labeling from list task was approaching significance. A repeated measures Analysis of Variance model indicated a difference between at least two of the three tasks, F (2, 26) = 4.563, p=0.015. Pairwise comparisons indicated a significant difference between each of the map labeling tasks and the free sketch map tasks, (free sketch vs. labeling, t (28) = 2.468, p=.02; free sketch vs. labeling from list, t (28) = 2.011, p=.054).

It was hoped that comparisons based on the course of enrolment (introductory geography vs. senior geography), the number of geography courses taken, and sex would provide interesting results related to how we express geographic knowledge and role that different types of geographic training plays in the development of geographic knowledge. Unfortunately the rate of participation by students in the two geography classes made this impossible. Of the thirty participants only seven came from the senior geography class, furthermore, of the total sample twenty-four were females. Comparisons between groups of such different sizes can affect the validity of statistical analysis; therefore, these comparisons will be tabled, at least until a larger sample is collected. One interesting implication of these differences is the relative likelihood of participants volunteering for the study and group membership. That more student participants came from the introductory class is not surprising; there were 153 students enrolled at the time of testing, compared to fifty-six in the senior class. On the other hand the number of males and females in each was approximately the same, indicating that female participation in the study was much more likely than male participation.

While the above pattern of participation was disappointing further evaluation of the relationships among the tasks for the entire participant sample was pursued. That differences exist between the individual tasks was a first step; a comparison of these results with performance on the drawing and spatial memory tasks was next. Performance on the copying and spatial memory tasks indicated that the two were measuring different abilities. The mean score on the copying tasks was 29.4 (out of a total possible of 36), while mean for the memory task was 19.6. Using a repeated measures test this difference was significant, F (2, 26) = 59.257, p=0.000. As the scale of measurement for the three mapping tasks and the copying and drawing tasks was different, correlation analysis was used to examine the relationships among the various tasks.

Correlation Results:

Using the Pearson Product Moment correlation coefficient, performance on both the drawing and memory tasks were positively and significant correlated with the free sketch mapping task, r(29)=.393, p=.043 and r(29)=.385, p=.039, respectively (see Table 1 for complete table of correlation results). Neither the drawing nor the spatial memory task was correlated with either the map labeling or map labeling from list task. This suggests a relationship between the non-geographic abilities represented by the drawing and drawing from memory tasks and the free sketch map task. In order to examine the potential difference between the mapping task that included some drawing ability and those mapping tasks relying less heavily on drawing ability correlations were calculated between the three mapping tasks. Unfortunately these results were not as clear as was hoped. While the two labeling tasks were strongly positively correlated, r(29)=.919, p=.000, the labeling from memory (no country list) was also positively correlated with the free sketch mapping task, r(29)=.525, p=.003.

Table 1: *Correlation results. Bold indicates significant Pearson correlation.*

	Free Sketch	List Labeling	Memory Labeling	Copying	Memory
Free Sketch P	1	**0.525** 0.003	0.35 0.063	**0.385** 0.039	**0.393** 0.043
List Labeling P	0.525 0.003	1	**0.919** 0	0.272 0.153	0.244 0.221
Memory Labeling P	0.35 0.063	**0.919** 0	1	0.297 0.117	0.22 0.269
Copying P	**0.385** 0.039	0.272 0.153	0.297 0.117	1	0.36 0.65
Memory P	**0.393** 0.043	0.244 0.221	0.22 0.269	0.36 0.65	1

Discussion

The results of student performance on these relatively straightforward sketch mapping tasks and two more abstract drawing tasks (copying and memory) provide interesting insight into the validity of sketch mapping tasks for evaluating geographic knowledge. In the past researchers have evaluated sketch map output based on both geographic content and drawing ability, but have had difficulty differentiating between the two (Saarinen 1999, 1973). While using drawing ability to measure geographic knowledge (accuracy of country or continental outlines) has been critiqued in the past (Golledge 1987), there have been few attempts to examine the role that drawing ability has on sketch map performance as a measure of geographic knowledge. The current study controlled the dependent variables to those related strictly to geographic knowledge (country names), in an attempt to eliminate, as much as possible, the role that drawing ability played in performance. Even with this control, differences in geographic knowledge as expressed in different sketch mapping tasks occurred.

The first important result of this study was the relationship between the two drawing specific tasks (non-geographic) and the geographic sketch map task that included the strongest drawing component. This result indicated that there was a relationship among drawing, copying, and geographic knowledge as expressed in a free sketch mapping task. Interestingly, there was no correlation between the two non-geographic sketching tasks (complex figure, copying and memory), yet both were related to the number of countries labeled on the free sketch map. This implies that while drawing accuracy (as measured by the copying task) and memory of spatial relationships (as measured by the final memory task) are not correlated, each is related to performance on the free sketch task. This might have been affected by the way each map was scored, the free sketch map scoring did not measure the correct placement of country names, just the inclusion of a countries name on the sketched map. This ability seems related to one's ability to draw complex figures (e.g. country and continental outlines) and remember the complex spatial relationships between shapes and objects (e.g. the relative position of countries, continents, and oceans). The author sees no way to escape this situation as the free sketch maps cover a wide range of drawing ability. Furthermore, the labeling task allowed for the inclusion of correct country labels and it seems reasonable to use this information, even to the point of being unavoidable.

Additionally, the relationships among the mapping tasks themselves seem to provide evidence for the complicated processes at work when trying to recall spatial and geographic knowledge. The final mapping task (map labeling from a list) was a purely spatial (geographic location) task, participants did not have to remember country names, they had to relate each country name to the correct outline on the world map. The second map task (labeling from memory) shared components of both the free sketch map and map labeling from list tasks. Participants had to recall country names from memory (as in the free sketch map task), but were provided the spatial cue of world location and country shape (as in the map labeling from memory task). Based on the correlation analysis this task may have more in common with the map labeling from list task than the free sketch mapping task, although it clearly has ties to each. That the final mapping task was only correlated with the labeling from memory task indicates that relating country name (not from memory) to its correct shape and geographic location has more to with spatial, or geographic, knowledge than to drawing ability or ability to draw geographic phenomena (e.g. countries, continents, and oceans).

Conclusions

Sketch maps have a long history as a technique for eliciting both spatial and geographic knowledge (Saarinen 1973, Ladd 1970, Moore 1974). They have been used in a variety of disciplines and have been used as principal and contributing measurement devices in a range of experimental studies (Blades 1990, Saarinen 1999). Many researchers, several of them avid users of sketch mapping devices, have commented on and questioned the validity of sketch mapping and the complicity of drawing ability and other potential confounding variables in the process of producing sketch maps and other spatial diagrams (Golledge 1987, Siegel and Cousins 1985). The current study exposes more explicitly some of the advantages and disadvantages of general styles of sketch mapping and the relationship each has to geographic/spatial knowledge and drawing ability (copying and spatial relation recall). Free sketch mapping tasks that require the expression of spatial components and relationships require greater drawing ability than those tasks that rely less on these non-geographic (in this case) drawing abilities. Future work can build on this understanding and develop more thorough models of the relationship between the non-geographic abilities that inhibit sketch mapping from revealing more truly the nature of geographic knowledge.

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