Mapping topological relationships in context

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Abstract: In order to better understand how people construct maps when they are located within the setting they are mapping, we compared how people drew maps between two contexts. Thirty subjects drew maps that included three topological features: the lagoon, the edge of Lake Michigan, and the land between these two bodies of water. We present preliminary data that suggests the accuracy and coherence of the maps generally improved with experience in both contexts.

Motivation

Using and building maps to see the big picture is a complex cognitive task, drawing upon direct perception and requiring reasoning with multiple pieces of spatial information visualized from different perspectives (Uttal, 2000). Constructing a map view of a large-scale local landscape requires knowledge for building relationships among topological features as well as strategies for thinking about space as a collection of organized and systematic relations among features that fit into a coherent whole (Liben, 2006; NRC, 2006). In taking a situated approach to thinking and learning (Greeno, 1998), our motivation with this exploratory study was to understand how mapping a local landscape depends on the context in which the mapping is located. In particular, we were interested in knowing how people construct maps when they are located within the setting they are mapping, and how direct navigational experiences compare to mapping from digital photographs.

Procedure

Of the 30 adults recruited through flyers posted around campus, 23 were students, and seven were university staff, neighbors, or former students. Subjects were randomly assigned to either the indoor or the outdoor condition. Each subject was fitted with a digital audio and video camera that attached to the bill of a hat and continuously recorded what was said and how the maps were drawn.

In the outdoor condition, 14 subjects walked around a man-made lagoon while being clinically interviewed about the lagoon and surrounding "lakefill," stopping periodically to complete a variety of interview tasks (see Figure 1). In the other condition, 16 subjects were clinically interviewed as they viewed photographs of the lakefill on a computer screen inside a building near the lagoon, These subjects were asked to imagine they were on a walk around part of the lagoon and viewed eight high-resolution panoramic digital photographs shot from strategic points on the lakefill. Each interview lasted approximately 45 minutes and followed the same semi-structured protocol that included questions about the history and future of this part of the campus and predictions about how the lagoon could change over various spans of time.

Partway into the interview, the subjects were handed a clipboard, white typing paper, and a pen and asked to draw a map that shows the entire lagoon, the edge of Lake Michigan, and the land beside the lake and the lagoon. Near the end of each interview, the subjects drew a second map and were provided the same instructions to do so. After each mapping task, subjects described the map they drew, how they drew it, and they indicated north, if they hadn't already done so. We measured the three principal topological relationships the subjects mapped and compared them to the actual ratios.

Preliminary Findings

In both conditions, the mapping tasks started and ended at approximately the same time during the interview (see Table 1). The indoor interviews lasted on average about 15% longer than the outdoor interviews mostly due to additional time needed for image resizing and management and toggling between photographs. The mapping tasks usually lasted around three minutes, with the exception of the second outdoor mapping task, which took noticeably less time to complete.

Initially, in the outdoor condition, subjects tended to map the lagoon as an elongated oval shape ($NS/EW_{lagoon} > 1$) with a wide patch of land depicted between the lagoon and the Lake ($EW_{lagoon}/ EW_{Land}. \leq 1$) (see Table 2). In the indoor condition, however, the lagoon was typically represented relatively long, but without much space for land between the lagoon and the Lake. In both conditions, after having seen and experienced more of the lakefill, or perhaps having had the experience mapping, subjects drew the relationships among features closer to the actual values, portraying the lagoon more like a bulb or bean than like an oval and depicting the land beside the Lake relatively more narrow (see Figure 2A). Interestingly, after walking around the lagoon, more than twice as many subjects in the outdoor condition (n=8) than subjects who mapped from photographs in the indoor condition (n=3) lengthened the lagoon by including the football field shaped feature near its southern tip (see Figure 2B). This observation suggests that certain features of this landscape may be easier to grasp by being in the actual location than by viewing representations of that place. We find that constructing maps from digital photographs, just like being in the location being mapped, can be a productive and meaningful context for representing a local landscape. Future work will investigate how learners construct and use maps and other symbolic representations to learn science across contexts, in class and on field trips.

Figures and Tables

Table 1: Average interview length and durations of mapping tasks within and across contexts.

Time (min:sec)	Outdoor	Indoor
Average Interview Length	42:06	49:48
Average Start-Finish Times for First Mapping Task	11:24 - 14:50 (3:26)	14:09 - 17:28 (3:19)
Average Start-Finish Times for Second Mapping Task	35:40 - 38:00 (2:20)	43:00 - 45:54 (2:54)

Table 2: Average ratios of distances between three topological features.

	First Mapping Task		Second Mapping Task		Actual Ratio
Topological Relationship	**Outdoor**	**Indoor**	**Outdoor**	**Indoor**	
EW_{lagoon}/ EW_{Land}	1.3	2.0	2.0	2.5	3.0
NS/EW_{Land}	3.6	5.7	5.5	4.2	3.8
NS/EW_{lagoon}	2.2	1.5	1.6	1.5	1.3

Figure 1. The route walked or viewed through photographic representations during each interview.

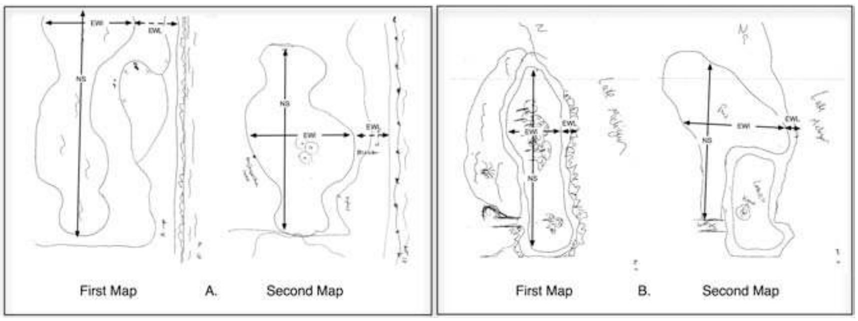

Figure 2. Two example drawings. A. At the widest part of the lagoon, note the shift in lagoon width relative to land width. B. This subject chose to include a rectangular tail toward the south.

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