Analysis of College Students' Spatial Knowledge and Misconceptions Related to Earthquakes and Volcanoes

Meredith Beilfuss

INTRODUCTION

Although a significant amount of educational research has been carried out in fields such as physics and chemistry, the number of studies that have been conducted in physical geography and earth science has been limited. While students' conceptual understanding of the Earth in space, Earth's atmosphere, and Earth's oceans have been studied, several other aspects of the Earth system have not been studied in any depth. In addition, the impact of physical geography on student ideas about the Earth is rarely discussed. The study described in this paper expands the field of misconception research by focusing on student conceptions of the locations and processes of earthquakes and volcanoes.

LITERATURE REVIEW

The causes and locations of earthquakes and volcanoes are typically taught beginning in grade six and extending through high school and college courses. However, students often acquire a considerable amount of knowledge through life experiences and media/technological sources prior to formal instruction about these concepts. Teachers should be aware of possible student misconceptions and then develop instructional strategies that will address these misconceptions.

A large amount of research has been conducted with regard to college students' understanding of concepts in science. It has been observed that students' conceptions are often inconsistent with scientific thinking and can be viewed as pseudo-scientific or non-scientific (Stead and Osborne 1980). These conceptions have been referred to as "naive beliefs", "preconceptions", "alternative conceptions" or "misconceptions" (Bezzi and Happs 1994). Some prior work has been conducted on younger students' conceptions of earthquakes and volcanoes. For instance, a study by Ross and Shuell (1993) revealed that although younger students had no problems connecting the shaking of the earth to an earthquake event, they could not explain what actually caused the earthquake. In addition, Leather's (1987) study found that almost half of the 11-14 year-olds in his study thought that earthquakes occurred in hot countries. Sharp et al. (1995) observed similar findings in a small study of nine to ten-year-olds in the United Kingdom. However, a search of the published literature failed to locate a significant number of studies that are directly concerned with college student's beliefs about earthquakes and volcanoes relative to their spatial knowledge of these phenomena.

Research topics in geography education may rely, to a certain degree, on the elements and standards presented in *Geography for Life, The National Geography Standards* (GESP 1994). The first essential element, "The world in spatial terms" outlines the analysis and internal and external representation of geographic and spatial information as a primary goal of geographic educators (cf. GESP 1994, 61-64). The present study was designed to measure students': 1) configurational knowledge (knowledge of the associations between and relative locations of places), and 2) declarative knowledge (prior knowledge) of the spatial patterns and areal relationships that help explain earthquakes and volcanoes.

METHODS

Interview Protocol

In order to research students' declarative and configurational knowledge, 45 interviews were conducted with students from an entry-level geoscience course. Interviewees ranged in age from 18-25, with the majority of the students being freshmen or sophomores in their college standing. Interviewees were 76% female, typically Caucasian, and not academically anticipating to major in science. Interviewees were recruited through an extra credit offering, and most of the interviews occurred in the latter half of the semester, after students had been exposed to many of the physical science topics investigated in the interviews.

The interview protocol was designed as a semi-structured question and response interaction between interviewer and interviewee. Protocol questions guided the initial discussion, while verbal probes and in-depth questions were used to encourage students to explain responses. Suggested probes were included in the protocol, although the interviewer was given freedom to develop probes as needed. Interviews typically consisted of one to four questions, and were between one-half and one hour in duration. Interview topics were developed from a review of topics typically included in introductory and general education geosciences textbooks, and included topics other than volcanoes and earthquakes. This paper presents only the responses from earthquake and volcano questions.

The protocol for the research began by requesting interviewees to mark locations on a world map (Figure 1), as a form of cued sketch mapping. It was judged that the mapping of locations of earthquakes and volcanoes was

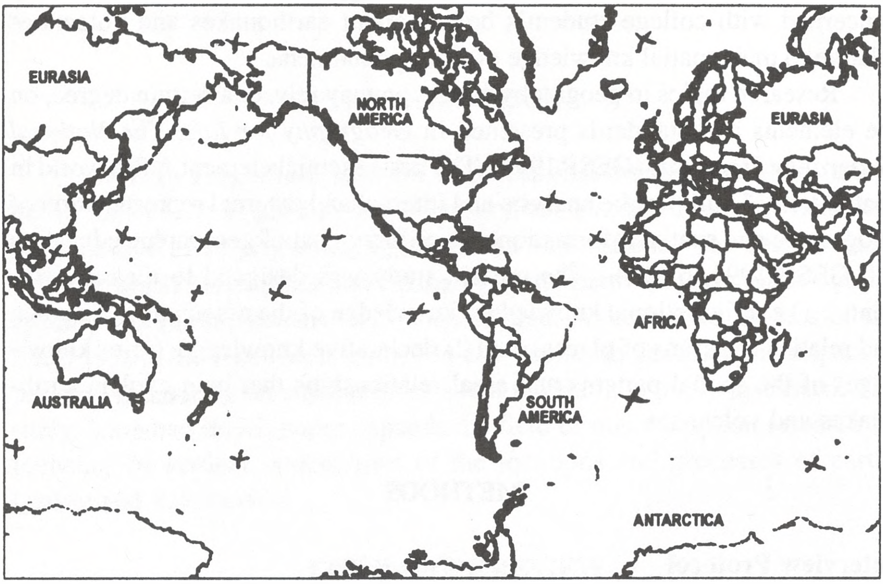

Figure 1. A student's perception of volcano locations.

necessary to investigate student beliefs regarding the causes of such phenomena. The interviews were audio taped to permit later review, transcription, and analysis of student responses.

Scoring Student Responses

Interview Responses

The interviews were taped and the transcripts coded by the researchers. Student responses were used as the basis for qualitative methodology using content coding that was then used in the analysis to reveal patterns in the interview transcription. The coding categories were identified inductively from the interview data and are discussed in Libarkin et al. (2002, in review). Briefly, the coding categories consisted of identifying students' conceptual levels as ranging from a MATTER viewpoint (i.e., volcanoes are simply objects on the earth) to a PROCESS viewpoint (i.e., volcanoes occur due to specific geologic processes within the earth). All interviews were also analyzed with reference to students' misconceptions of earthquake and volcano phenomena. The interviews were used to confirm and assess students' mental models of the distribution of earthquakes and volcanoes.

Codifying Mapped Data

The scaling of performance scores on the mapping and interview tasks remains a complex question. The review of the literature and paradigms that have been used by others, and which may be modified for the present study, continue to provide viable options. The maps were scored using a technique developed by the researchers. This technique was used due to the small sample size (N = 50 maps), and the large range of marked locations for these phenomena on student maps. Each student was assigned two scores for each map: a location response score and a location accuracy score. First, the number of locations (N), that were marked on each student map was determined. For example, the student map in Figure 1 has 27 marked locations, therefore N = 27. Then, using the range of location responses observed in all the students' maps, a series of categories for the number of responses on each interviewee's map was selected. The number of locational responses, indicating either volcanoes or earthquakes, were classified into the following groupings: 1-3, 4-9, 10-14, 15-24, and 25-56. The categories of responses were selected using the range and central tendency of the response data (Figure 2). Individual interviewee performance, as determined by the number of locations marked on the student map, was then given a location response score (L) value: 1 point for having 1-3 locations, 2 points for 4-9 locations, 3 points for 10-14 locations, 4 points for 15-24 locations and 5 points for 25-56

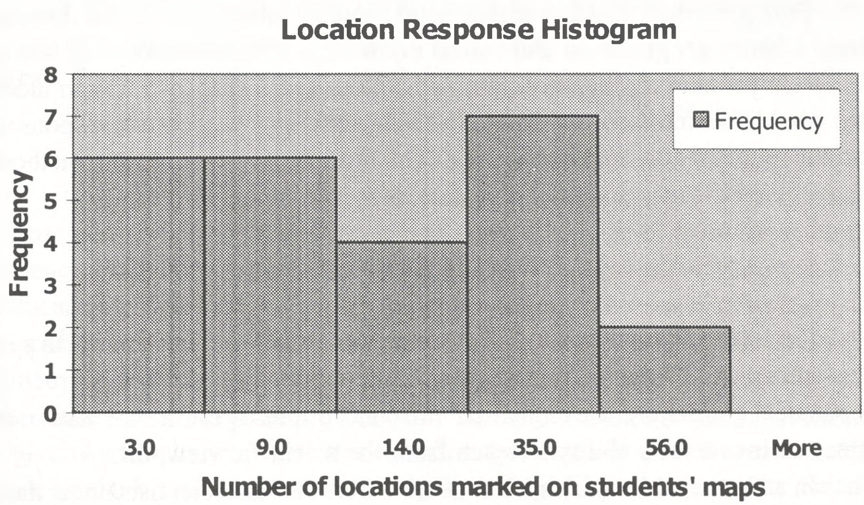

Figure 2. Histogram of locational responses on students' earthquake maps.

locations. For example, the location response score assigned to the student map in Figure 1 would be L = 5. The apparent unevenness in assigning a category for the number of marked responses is due to the wide range of student responses on the maps. This process of assigning categories for marked responses enabled the researchers to assign each student a score that represented the extent of their greater knowledge of the locations for earthquakes and volcanoes as a world-wide phenomenon. A higher location response score (L) reflected the student's knowledge of the spatial distribution of these phenomena across the earth's surface.

The next step in the scoring process was to assign each student map with a location accuracy score (S). Reference maps for volcanoes and earthquakes were used to standardize the scoring and judge map accuracy. While the location accuracy scoring procedures required some judgment by the scorer, the map templates did enable the scorer to identify patterns of inaccuracy or randomness in the marked locations on the maps. A location accuracy score was assigned by summing the total number of correct locations (C), divided by the total number of locations suggested by the student (N), to yield a percentage score for each interviewee.

$$S = C/N \times 100 \qquad (1)$$

Since a student with a large number of locations may also make accurate locations by chance, we accounted for this possibility by computing a total score (T). This was calculated using the number of correct locations, multiplying it by the location accuracy score (S), and summing that with the location response score (L), obtained in the initial procedure. This yielded a total map score for each student map (T).

$$T = (C \times S) + L \qquad (2)$$

This procedure yields a higher total score to interviewees who demonstrate a better geographical and causal knowledge of earthquakes and volcanoes. On further consideration, it may be more applicable to create an index that would take into account the overall range of responses, correct responses, and the range of attempted responses. The most appropriate scoring methodology, given the map and interview data, is still being explored.

IMPLICATIONS

Students exhibit a variety of misconceptions about Earth and earth system processes. Certainly, this study has implications for science instruction in physical geography. Strongly held misconceptions of Earth processes may affect an instructor's ability to teach from the scientific viewpoint.

In addition, although physical geographers and geoscientists understand this interplay between processes and spatial distributions of these phenomena, how likely are students to grasp this complex interaction? Even with plate boundary maps included in physical geography texts, the learner may chose not to allocate much study time to the material included in the map.

Are students conceptualizing the spatial distribution of these phenomena and their relation to Earth processes? If maps play an important role in students' spatial learning, then students who use a map as an aid to recall information should do better at recalling spatial relationships than those students who do not use a map as a cue for accessing prior knowledge. This may be important for future studies that seek to measure students' declarative, as well as, configurational knowledge.

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Meredith Beilfuss is presently a doctoral student of science education at Indiana University-Bloomington. Beilfuss is currently funded by an NSF grant to study undergraduate students conceptions of geoscience. Contact information: Science Education, Indiana University, 201 N. Rose Ave., Bloomington, IN 47405.