

Enhancing Quantitative Skills of Physical-Geology Students with a Geologic Compass

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ABSTRACT

Although the ability to use a geologic compass is an important skill for geologists and can be a useful and stimulating skill for any student, most introductory geology courses do not include any work on the use of the compass. This is unfortunate since compass work, introduced early, can help improve the quantitative skills of all students by giving them hands-on experience at solving practical problems. The equipment needed is readily available at relatively low cost and a variety of compass-based exercises can be designed to strengthen student skills. Worthwhile exercises include the following topics: quadrant and azimuth notation, magnetic declination, compass-traverse closure, elevation measurement, distance between two landmarks, and strike and dip.

Keywords: Apparatus; education – geoscience; education – undergraduate; field trips, field study, summer courses; geology – teaching and curriculum; miscellaneous and mathematical geology.

INTRODUCTION

Physical-geology textbooks and lab manuals generally fail to promote the geologic compass as an effective teaching tool. In the United States, geology students traditionally do not receive rigorous training in the use of the compass until they enroll in a field-geology course, usually during the junior or senior year.

The geologic compass has been an indispensable field-geology research tool for decades (Bartlett, 2000; Reed, 2000), and teaching physical-geology students how to use one complements a course in which both geology majors and non-majors are enrolled. Our justification for teaching compass skills during two consecutive three-hour physical labs includes the enthusiastic verbal response we have had from students. Most of them said they enjoyed the experience of learning to use an instrument that many professional geologists use. Some students said the compass skills they learned were useful in locating themselves on a map while hiking. All students felt that learning to use a compass helped them understand angular measurements better than pictures in a book because it gave them something more concrete to work with. Other students in various disciplines are contemplating undergraduate field-research projects requiring compass skills. One such project, already underway by a biology major, involves collecting water samples for analysis from wells and streams in Emanuel and Johnson Counties, Georgia. A compass is being used

in this project to determine the bearing and distance between collecting localities.

The authors believe that all educated individuals, regardless of their profession, should possess some quantitative skills in angular measurement. The geologic compass is an excellent tool for teaching these skills to all physical-geology students, regardless of their mathematical background, while providing them with the added benefits students themselves claim to receive. The purpose of this paper, then, is to promote the geologic compass as a worthwhile complement to physical-geology courses by emphasizing its usefulness in building quantitative skills based on the kinds of activities and calculations that many geologists do while working in the field.

COMPASS SUPPLIES AND EXERCISES

A variety of geologic compasses are available on the market. Those offered by the Brunton, Silva, and Suunto companies are the most popular, with various models in different price ranges. One particularly nice kit that is useful for classroom teaching is the Brunton compass and map-training kit illustrated in Figure 1.

Software and textbooks useful for teaching and learning compass skills include those authored by Hassinen (1998) and Compton (1985), respectively.

An instructor can design many different kinds of compass exercises. Topics we have covered include quadrant and azimuth notation, magnetic declination, compass-traverse closure, elevation measurements, calculating the distance between two landmarks, and measuring and plotting strike and dip. We use trigonometry in our compass-related exercises because it increases the number and complexity of the quantitative exercises students can learn to do. Consequently, students are introduced to or given a review of the fundamentals of right-triangle trigonometry and the law of sines and cosines before being taught how to use the compass. The following exercises are examples of compass-based exercises we find useful for enhancing student quantitative skills. Trexler (2000) and Dickinson and Hill (1997) have described additional practical examples of the importance of compass skills.

Quadrant and Azimuth Notation

This simple exercise requires students to plot angles on a sheet of paper and to convert between quadrant and azimuth notation, something many of our students don't initially know how to do. Students are then required to take compass bearings first between designated landmarks on campus and then between



Figure 1. Brunton kit for classroom instruction includes 24 Brunton field compasses, an instructor's guide, instruction booklets and worksheets, topographic maps and map symbol sheets, and a color VHS video with compass lessons on topics ranging from magnetic declination to triangulation. The kit is reasonably priced at about \$325 US.

points on a topographic map. They must then convert between the two types of notation. After completion of this exercise, a written quiz is administered to make sure students have mastered the necessary concepts. This exercise is easy for students to master, and many of them seem delighted that they are able to use an instrument to make the kinds of measurements and angular conversions that geologists do. In addition, this exercise is a good lead-in to more complicated compass problems requiring calculation of the distance between two landmarks using the law of sines or cosines as discussed later on.

Magnetic Declination

After distinguishing between the geographic and magnetic poles and discussing the significance of magnetic declination, students are required to interpolate declinations on an isogonic map by proportion and to contour interpolated declinations by hand. This exercise exposes students to another use of proportions in geology besides map scales and requires them to solve simple equations for unknown declinations. Because of the calculations

required before contouring, this exercise is more complicated than the simple topographic map contouring that physical-geology students do by connecting point elevations on a two-dimensional surface. It demonstrates to students the procedure a mapping geologist might have to use in order to determine the declination to which his or her compass must be set for accurate fieldwork.

Elevation Measurement

Students are required to determine the height of a building (Figure 2B) by using the tangent function. This skill may then be utilized in the field for calculating the height of a cliff if, for example, it is necessary to determine the thickness of an exposed outcrop of horizontal sedimentary strata. The exercise requires students to measure their distance from a building on campus and then the angle from the horizontal at eye level to the top of the building. The tangent function is used to calculate H_2 , illustrated in Figure 2B, and this distance is added to H_1 , the student's height, to determine the actual elevation of the building (or a cliff). Many students are surprised that it is possible to determine the height of a building without hanging a rope off the side and measuring its length.

Distance Between Two Landmarks

In this exercise, students use a compass to measure bearings between landmarks on campus. They also pace off the distance between these landmarks on dry land. After determining the angles between bearing lines, they use the law of sines or cosines to calculate the distance between two landmarks separated by a pond, as illustrated in Figures 2C and 2D. All our students immediately realize the usefulness in applying mathematical formulae to compass data acquired in the field – the distance across a pond can be determined without getting your feet wet. The law of sines is another example of using proportions in geology, and the law of cosines requires to students to determine the square root of a number after calculating with exponents and the sine and cosine functions.

Strike and Dip

In this exercise, students measure the strike and dip of an inclined plane in the lab (Figure 2E) and then on several bedding planes in the field. We have found that the performance of students on structural-geology exercises in their physical-geology laboratory manuals is enhanced after they learn to measure strike and dip (Stracher and Shea, 1999). Students report that they feel more comfortable plotting strike and dip symbols in their laboratory manuals and that the significance of these symbols in revealing the presence of folds on a map is more readily understood.

CONCLUSIONS

The geologic compass is an effective tool for enhancing quantitative skills because it promotes learning by doing. Developing and using compass-based exercises is an inexpensive, convenient, and practical way of enhancing quantitative skills including interpolation and trigonometry. Such exercises have the added benefit of providing students with an appreciation for a valuable research tool and the way it is used by many geologists while doing fieldwork. In addition, students are taught a skill useful for hiking and some undergraduate research projects and quite possibly useful later in their professional careers.

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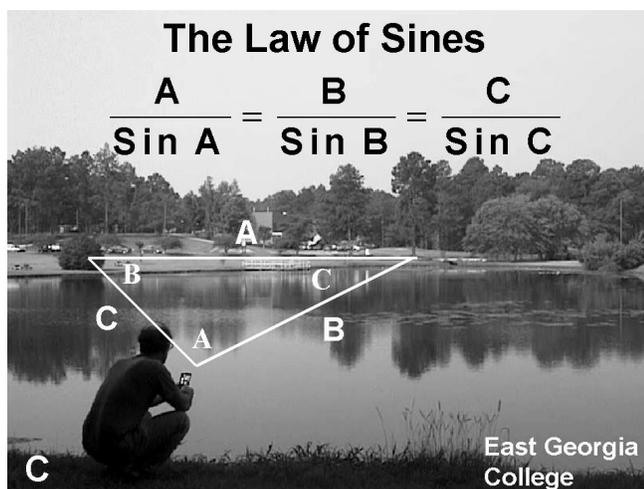
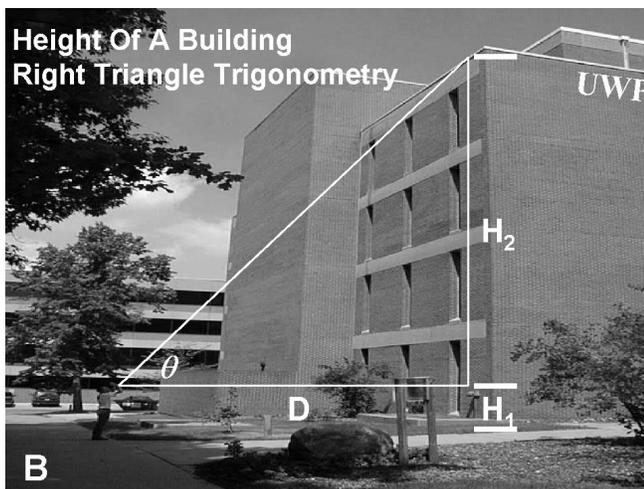
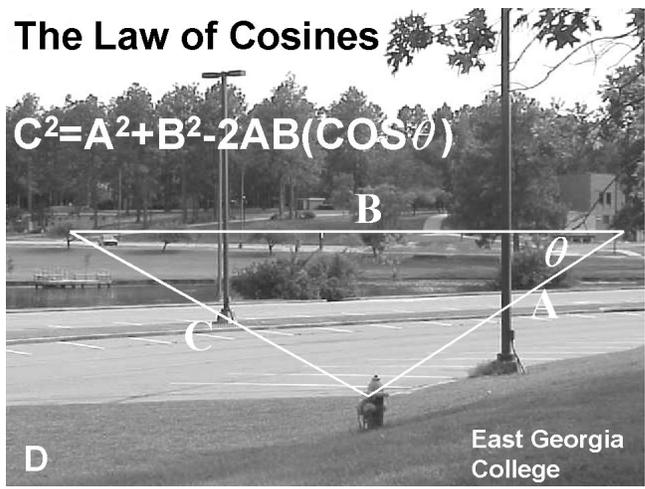


Figure 2. Compass exercises designed to enhance quantitative skills, especially working with angles. Exercises include: calculating closure for a compass traverse (A), measuring the height of a building (B), using the law of sines (C) or cosines (D) to calculate the distance between two landmarks, and using a compass with a clinometer to measure the strike and dip of an inclined plane (E).

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Glenn B. Stracher is Associate Professor of Geology at East Georgia College in Swainsboro, Georgia. He has been active in undergraduate quantitative-skills education. During the past four years, he has taught geochemical thermodynamics at the graduate level in the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology. Glenn is currently developing a WebCT course in thermodynamics for Georgia Tech. He is co-author of a two-volume textbook in chemical thermodynamics, recently translated into Japanese, and is currently co-authoring a new book in chemical thermodynamics for engineers and earth scientists.

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