Journal of Outdoor Recreation, Education, and Leadership 2015, Vol. 7, No. 2, pp. 158–165
http://dx.doi.org/10.18666/JOREL-2015-V7-I2-7010

Comparison of Methods to Teach Magnetic Declination

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Abstract

Compasses continue to be essential equipment for outdoor navigation; however, it is challenging for some students to learn how to use a map and compass effectively and efficiently. Perhaps one of the most challenging issues is understanding and applying magnetic declination. There are multiple methods of accounting for declination; however, most sources of printed instruction and likely many individuals stick to one method of working with declination. The purpose of this article was to present four methods of accounting for magnetic declination. The intention of systematically presenting these methods was to increase awareness, facilitate a comparison, and spur further investigation into the efficacy of the different methods.

KEYWORDS: navigation; teaching methods; outdoor recreation

Navigation can be one of the most challenging and most useful skills for outdoor enthusiasts to master. Anyone who has spent time in the backcountry with a group of intermediate or experienced outdoor recreationists may likely have witnessed (or participated in) arguments about what is the right way to use a map and compass. One particularly challenging navigational issue is resolving the difference between aligning a map with true north (TN) and pointing a compass needle at magnetic north (MN).

Although two or more methods for resolving declination are presented in some sources (e.g., Drury, Bonney, Berman, & Wagstaff, 2005; Goulet, 2001; The Mountaineers, 1997), only one method of resolving the declination issue is presented in most sources (Ford & Blanchard, 1993) or slight variations on the same method (e.g., U.S. Geological Survey, 2014). Similarly, in my experience, outdoor educators tend to be dogmatic in their approach to teaching map and compass, claiming their favored method is the correct method. This article is unique in that I describe four methods for resolving the magnetic declination issue to increase awareness, facilitate a comparison, and provide a resource for further investigation into the efficacy of the methods used in accounting for magnetic declination.

Compasses are useful because they can help users relate the information on maps to the world around them or conversely relate surrounding features to the map. However, for compasses and maps to be useful, compass users need to know that compass needles point to MN and maps are generally oriented to TN. More precisely, compass needles point along the horizontal component of the magnetic field (National Oceanic and Atmospheric Administration, 2014). The angle of difference between TN and MN is called the magnetic declination (Natural Resources Canada, 2013).

It may be argued that a conversation about declination is dated since the increasing use of Global Positioning System (GPS) has shifted compasses to the role of a distant backup for the superior GPS unit (Groundspeak, 2012). GPS receivers are increasingly becoming part of outdoor navigation curricula (e.g., National Outdoor Leadership School, 2014). Worldwide, the GPS sport of geocaching has more than 10 million users registered at the popular website Geocaching.com looking for over 2.5 million geocaches (Groundspeak, 2015). Moreover, better smartphone applications that use GPS signals with integrated maps are changing the way people navigate in their daily lives (e.g., EeeNetLive, 2014; Happy Magenta, 2010). The counter argument is maps and compasses are generally more dependable, more durable, simpler (do not require batteries), lighter, and cheaper than many GPS devices (Barcelona Field Studies Centre S.L., 2013; Ingraham, 2009). Therefore, it is still important to understand the different methods of adjusting for magnetic declination.

To facilitate the discussion of declination, a compass diagram is presented in Figure 1 with the associated names for each part. Many parts of a compass have a variety of commonly used names (e.g., orienteering arrow vs. shed).

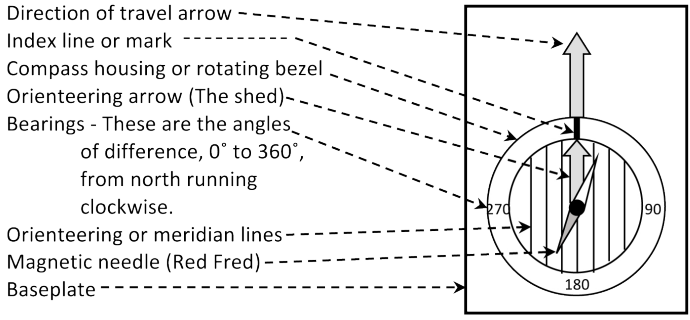

Figure 1. Compass nomenclature for a simple orienteering compass.

Methods to Teach Magnetic Declination

There are multiple ways to resolve the issue of magnetic declination in outdoor navigation. Four of the more popular methods presented in texts and that I have observed in the field are described next. Although these methods for resolving magnetic declination are presented as unified methods, it is possible to use hybrids of the following methods.

Always Talk True

This method is focused on always finding and using true bearings. The difference between TN and MN is resolved kinesthetically rather than mathematically. This is the method Ford and Blanchard (1993) present in their classic outdoor education text. In their presentation, it is assumed the orienteering arrow and lines have not been adjusted; however, the method is almost identical if a compass has an orienteering arrow that can be adjusted to give a visual reference for magnetic declination ("set-and-forget" [e.g., Burns & Burns, 2004] or "red Fred in the shed" [e.g., Ingraham, 2009] methods).

Getting a bearing from a map. In this method, the compass is used as a protractor to measure a bearing. The magnetic needle is not used to get a bearing from the map.

1. The user aligns the edge of the baseplate between the two landmarks with the direction of travel arrow pointing along the desired direction of travel or toward the landmark the user wants to know what direction is relative to the user's current location.
2. The user then turns the compass housing until the orienting lines are parallel to the edge of the map and the "N" (0˚ or 360˚) on the compass housing is pointing at the top of the map.
3. The true bearing between these two landmarks can then be read at the index line.

Plotting a bearing on land.

1. The user maintains or adjusts the compass housing so the desired true bearing is at the index line.
2. The user then holds the compass level. The direction of travel arrow must point away from the user.
3. The user rotates his or her body and the compass until the magnetic needle is pointing at the bearing indicated by the magnetic declination (the declination itself for an east declination or 360 minus the declination for a west declination). When the compass is level and the magnetic needle is pointing at the magnetic declination, the direction of travel arrow will be pointing at the bearing the user intends to plot.

Finding a bearing on land.

1. The user holds the compass level with the direction of the arrow pointing at the landmark for which the user wants to find the bearing relative to his or her present location.
2. The user rotates the compass housing until the magnetic needle is pointing at the magnetic declination.
3. The bearing at the index line is the true bearing of the landmark in question relative to the user.

Applying a bearing to the map. Similar to getting a bearing from a map, the compass is used as a protractor and the magnetic needle is forgotten. It is assumed the user has a bearing in relation to a present known location; however, the method is similar if using triangulation to identify the user's current location based on bearings from known landmarks.

1. The user maintains or turns the compass housing so the desired true bearing is at the index line.
2. The user places the compass flat on the map. The user puts the rear corner of the baseplate on the user's current known location.

3. The user pivots the compass on the landmark until the orienting lines are parallel to the side of the map and the "N" of the compass housing is pointing at the top of the map. The edge of the baseplate is now aligned along the desired bearing from the known current location.

Benefits. The first benefit of this method is the difference between magnetic and true bearings is adjusted kinesthetically and not mathematically. This is useful for users who may have difficulty doing mental math consistently with accuracy.

The second benefit is only one set of bearings is used. Therefore, if multiple individuals are cooperating on a navigational challenge, they can talk about bearings and know the bearings being discussed are always true and not magnetic bearings.

The third benefit to this method is the user can get or apply a bearing from or to a map and not need to use the magnetic needle. This allows the user to get or apply bearings from or to a map in a car or on a nonlevel surface on which the magnetic needle will not properly work.

Downsides. There are no obvious downsides to this method.

Orient and Stay Magnetic

This method is the opposite of Always Talk True. Rather than going through each of the steps, I will focus on how this method is different from the Always Talk True method.

Getting a bearing from a map.

1. The user orients the map so the top of the map is pointing at TN. One simple method of orienting a map requires a compass with a transparent baseplate.
    a. The user places the compass onto the magnetic declination angle diagram at the bottom of the map (or compass rose on nautical charts) so the pivot point of the magnetic needle is on the base of the angle on the map.
    b. The user then rotates the compass so the orienteering lines are parallel with the TN line (sometimes indicated with a star).
    c. The user rotates the map and compass together until the magnetic needle is aligned with the MN line.
2. The user aligns the edge of the baseplate so the direction of travel arrow is pointing toward the landmark of which he or she wants to know the bearing relative to the known (starting) landmark.
3. The user rotates the compass housing until the magnetic needle is pointing at "N."
4. The bearing at the index line is the magnetic bearing from the known landmark to the second landmark.

Plotting a bearing on land.

1. The user maintains or adjusts the compass housing so the desired magnetic bearing is at the index line.
2. The user then holds the compass level with the direction of travel arrow pointing away from his or her body.
3. The user rotates his or her body and the compass until the magnetic needle is pointing at "N."
4. The direction of travel arrow will now be pointing to the magnetic bearing that was intended to be plotted.

Finding a bearing on land.

1. The user holds the compass level with the direction of arrow pointing at the landmark for which the user wants to find the bearing relative to his or her present location.
2. The user then rotates the compass housing until the magnetic needle is pointing at "N" on the compass housing.
3. The bearing at the index line is the magnetic bearing to the landmark in question relative to the user.

Applying a bearing to the map.

1. The user orients the map to TN.
2. The user maintains or sets the magnetic bearing to the index line.
3. The user places the corner of the baseplate of the compass on the known landmark.
4. The user rotates the compass until the magnetic needle is pointing at "N" on the compass housing. The baseplate is now aligned along the bearing relative to the known landmark.

Benefits. Although the user may orient the map to TN in Always Talk True, Orient and Stay Magnetic requires the user to orient the map. This required step may help users connect the features on land to what they can see on the map. Moreover, the angle of the compass does not change between the land and the map. In fact, students do not have to know the difference between TN and MN. As long as the map is oriented, this method works well.

Downsides. This method has two primary downsides. First, the map always needs to be oriented. If the user bumps the map or the wind slightly spins the map out of orientation to TN, this method will not work. Second, the compass needle needs to always be working. Therefore, this method cannot be used to get bearings if there is distracting metal (e.g., while traveling in cars or if there are bolts in a picnic table) or if the map is not on a level surface.

Mark That Map

The third method is slight variation of Orient and Stay Magnetic. Kjellström's (1976) described this method in a groundbreaking orienteering manual. The basic idea is parallel lines are drawn on the map at regular intervals. The lines are oriented along the magnetic north–south axis (versus the edge of the map, which is still oriented along the true north–south axis).

Getting a bearing from a map. The only difference between this and Always Talk True is the compass housing is turned to align the orienteering lines to the drawn lines aligned with magnetic north–south rather than the vertical lines on the map.

1. The user must first draw lines of magnetism on the map at regular intervals that are aligned to the magnetic north–south axis before the map can be used.
2. The user aligns the edge of the baseplate between the two landmarks with the direction of travel arrow pointing along the desired direction of travel or toward the landmark to which the user wants directions relative to his or her current location.
3. The user then turns the compass housing until the orienting lines are parallel to the lines of magnetism drawn on the map and the "N" on the compass housing is pointing toward the top of the map.
4. The magnetic bearing between these two landmarks can then be read at the index line.

Plotting a bearing on land.

Same as Orient and Stay Magnetic.

Finding a bearing on land.

Same as Orient and Stay Magnetic.

Applying a bearing to the map. Again, the only difference between this and Always Talk True is the compass housing is aligned to the magnetic north–south lines rather than the edge of the map.

1. The user maintains or turns the compass housing so the desired magnetic bearing is at the index line.
2. The user places the compass flat on the map and puts the rear corner of the baseplate on the user's current known location.
3. The user pivots the compass with the corner of the baseplate on the landmark until the orienteering lines are parallel to the lines of magnetism drawn on the map and the "N" of the compass housing is generally pointing toward the top of the map. The edge of the baseplate is now aligned along the desired bearing from the known landmark

(known current location or other landmark) and the direction of the unknown landmark (unknown current location or unknown other landmark).

Benefits. This method has all of the benefits of the Orient and Stay Magnetic method, plus the user does not have to keep the map oriented so the compass can be used as a protractor.

Downsides. The obvious downside to this method is the user must take the time to accurately mark a series of parallel lines on a map (typically before the backcountry trip begins). The marked lines may obscure features of the map. Moreover, if a user is in the field and does not have a parallel ruler and flat table, it may be difficult to draw these lines accurately. Finally, once a map is marked to a given declination, the user needs to erase and redraw the lines as the magnetic declination changes over time.

Mental Math

In this method, the user uses math, addition and subtraction, to resolve the declination issue rather than the kinesthetic method in the Always Talk True method. Multiple sources (Daniel & Stenger-Ramsey, 2009; Randall, 1989) recommend this method for individuals with compasses that do not have adjustable orienteering arrows, even though they acknowledge the superiority of the "set-and-forget" version of Always Talk True if you have an adjustable orienteering arrow.

Whether the user should add or subtract is different by where the user is located in comparison to the agonic line (where MN and TN are aligned). The following presentation is for a user west of the agonic line (e.g., Seattle). A user east of the agonic line (e.g., New York City) would add instead of subtract as suggested in these directions.

Getting a bearing from a map.

Same as Always Talk True.

Plotting a bearing on land. After the user adjusts the true bearing found on the map to a magnetic bearing, this process is the same as Orient and Stay Magnetic.

1. When the user shifts from the map to the land, the user needs to adjust the true bearing mathematically from the map to a magnetic bearing that can be used with the compass. Assuming the user is in Seattle, the user would subtract the declination from the true bearing to find the magnetic bearing.
2. The user then adjusts the compass housing so the desired magnetic bearing is at the index line.
3. The user then holds the compass level with the direction of travel arrow pointing away from his or her body.
4. The user rotates his or her body and the compass until the magnetic needle is pointing at "N."
5. The direction that the user and the direction of travel arrow are facing is the magnetic bearing that the user intended to determine.

Finding a bearing on land.

Same as Orient and Stay Magnetic.

Applying a bearing to the map. Now the user needs to adjust the magnetic bearing that was found on the land mathematically using the compass to the true bearing that can be used with the map. Assuming the user is in Seattle, the user adds the declination to the magnetic bearing to get the true bearing. After that, this step is the same as Always Talk True.

Benefits. The benefit is the user is able to use the compass as a protractor and not needing to mark up the map with the approximate lines of magnetism.

Downsides. This method has two major downsides. First, it may be difficult for navigators to convert the bearing consistently from true to magnetic and back from magnetic to true without making mathematical mistakes. This is especially true of novice navigators who may be already cognitively burdened trying to learn other aspects of using a map and compass. Experienced

navigators may similarly have difficulty if they spend most of their time consistently on one side of the agonic line and then need to switch to the other side. The second issue is it becomes more complex to communicate with other navigators. For example:

Navigator 1: "Mt. Baldy is at a bearing of 50˚."

Navigator 2: "Is that 50˚ true or magnetic."

Navigator 1: "True… I mean magnetic."

Even if the first navigator in this scenario is positive about whether the bearing is true or magnetic, it complicates communication to have to ask whether a bearing is true or magnetic. These issues increase opportunities for navigational mistakes.

Conclusions

The four methods of accounting for declination presented have different advantages (Table 1).

Table 1
Comparison of the Benefits of the Four Methods

Advantages	Always Talk True	Orient and Stay Magnetic	Mark That Map	Mental Math
No mental math required	X	X	X	
Only one set of bearings (true or magnetic) are discussed	X	X	X	
Can use the compass as a protractor with the map	X		X	X
Do not need to mark up the map	X	X		X

Three of the methods do not require math to adjust for true and magnetic bearings. The same three only require either magnetic or true bearings. This avoids potential confusion between which bearings are magnetic versus true. Three of the methods allow the user to use the compass as a protractor when getting a bearing from or applying a bearing to a map. This avoids needing to keep the map perfectly oriented during these steps. Finally, all but one method avoids needing to draw magnetic north–south lines on the map.

A comparison of the advantages shows Always Talk True is the only method that has all four advantages. However, other advantages and limitations not considered in this comparison may affect the user's ability to understand and perform these skills. Moreover, user and situational differences may also affect the efficacy and efficiency of the methods.

Research is necessary to ascertain the relative value of these methods in terms of their efficacy and the pedagogical processes that tend to work better or worse with different populations in various settings. The research design to answer this question is experimental or quasi-experimental in which groups of learners are randomly assigned to learn with one of the four methods and are then tested on their relative skill proficiency. I welcome collaborators on this research into the effectiveness and efficiency of modes of teaching declination.

Resolving the declination conundrum will likely continue to perplex and fascinate outdoor navigators. However, as outdoor educators, we are beholden upon to learn which method is most appropriate to teach, rather than staying dogmatically tied to a single method.

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