Question Design Based on Misconception Related to Weather Disaster Prevention

SHIGENO Tetsuhide [1]

Ryukoku University, Japan[1]

Abstract

This study analyzes the effects of the question design developed from the misconception study based on the data of students studying science pedagogy and liberal arts classes related to geology at the university where the author is in charge, on education in the field of geology from compulsory education to high school, as well as on weather disaster prevention for the general public, based on trials in university classes.

First, we analyzed what kind of misconceptions were generated by the descriptions and schematic diagrams in junior high school textbooks, and in particular, we examined whether the contents of the textbooks were designed to help students learn about weather disasters such as heavy rainfall. As a result, we concluded that the explanations and schematic diagrams of fronts, the description of cumulonimbus clouds, which are the main cause of weather disasters, and the schematic diagrams of precipitation areas are not consistent with the precipitation areas of heavy rains that have been frequent in recent years, and may be insufficient for learning about weather disaster prevention. In order to improve this situation, we report the effect of the question design developed from misconceptions.

Keywords: *Misconception, heavy rain, precipitation area, cumulonimbus cloud, middle school science, textbook diagram*

1. Location of the problem headings

Weather disasters include storms, heavy rain, heavy snow, tornadoes, and many others, but the most common cause of the torrential rains that have been occurring in recent years is heavy rain caused by cumulonimbus clouds. The term "linear precipitation zone" is now often used in weather forecasts as one of the causes of heavy rainfall. The term "linear precipitation belt" is often used in weather forecasting as a cause of heavy rainfall. All science textbooks for elementary and junior high schools include pictures of ten types of cloud formations, including pictures of cumulonimbus clouds.

The Japan Meteorological Agency (JMA) website describes cumulonimbus clouds as "clouds that are more than 10 km high and sometimes reach the stratosphere. Cumulonimbus clouds are also often seen in summer. The horizontal extent of a single cumulonimbus cloud is several km to more than ten km. A single cumulonimbus cloud can last from 30 minutes to an hour and is limited to a localized area. Cumulonimbus clouds are more likely to form when the weather conditions are "unstable. An unstable atmosphere is one in which there is a layer of cold air above and a layer of warm air on the ground. Convection tends to occur as warm air rises upward and cold air tries to descend downward. When the air near the ground is moist, the atmospheric conditions become even more unstable, and cumulonimbus clouds are more likely to develop. It says, "When the air near the ground is moist, atmospheric conditions become even more unstable and cumulonimbus clouds are more likely to develop.

However, in textbooks, along with the explanation of fronts, it is introduced that "cumulonimbus clouds develop near cold fronts, causing strong rainfall and strong winds", and in schematic diagrams, cumulonimbus clouds are depicted only near cold fronts, so most students think that they do not occur near warm fronts. In addition, there is no explanation that the clouds that bring snow to the Japan Sea side in winter are also cumulonimbus clouds. In reality, "unstable atmospheric conditions" are conducive to the formation of cumulonimbus clouds, and there is no understanding that the area where warm moisture flows in south of the front is a place where the atmospheric conditions are unstable and where cumulonimbus clouds are likely to form.

It also includes schematic diagrams of the movement of fronts and cyclones and the distribution of precipitation areas and changes in the weather. There is no cloud cover on the southern (warm) side of the front, and precipitation areas are drawn only on the cold side of the front. From the students' research, it was found that these images caused misconceptions, and they could not visualize what the situation would be like even though the weather report said that "atmospheric conditions are unstable" due to the inflow of warm moisture south of the front.

2. Research Methods

1.1 Learning to read the wind from weather maps

When asked to predict what kind of wind would blow based on the weather map, and to write the wind blowing on the weather map with arrows, most of the students could not correctly fill in the wind direction.

Although the textbook states that "winds blow clockwise out from the center of an anticyclone and counterclockwise toward the anticyclone around a low pressure system," the most common answer is as shown in Figure 1.

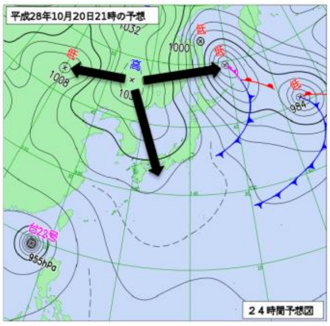

Figure 1　Most common responses from students

In reality, however, the wind does not blow as shown in Fig. 1, but rather the force due to the difference in atmospheric pressure (barometric tilt force) is combined with the "apparent force" of the rotation of the earth (Coriolis force), and frictional force with the earth's surface is also added. If you don't know how the wind actually blows, there is no point in studying weather maps, and you will end up with a simple understanding that high pressure systems are sunny and low pressure systems are rainy.

So, under the title "Reading the Wind from Weather Charts," I explain the following and repeat the exercise of filling in the wind direction on the weather maps. Tell the students the following two points.

(1) In the northern hemisphere, the wind blows parallel to the isobars, with the high pressure point on the right.

(2) The narrower the distance between the isobars, the stronger the wind.

In other words, we think that the isobars represent the wind direction and the wind blows along the isobars.

The wind direction then becomes as shown in Figure 2. In reality, the surface wind blows at an angle of 20° at sea and 30° on land with respect to the isobar due to frictional forces with the surface of the earth, in the direction of lower pressure. In fact, at altitudes of about 1 km or more, the wind direction is almost parallel to the isobars.

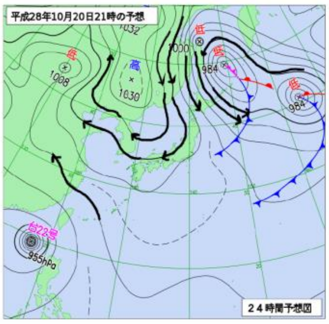

Figure 2 If we consider that the wind blows parallel to the isobar

If students can read the wind in this way, they can easily understand that the tip of the cold wind blowing from the north is a cold front, and that a front is a boundary between air with different properties and a place where winds with different properties collide.

As a result of this training using various weather maps, the students were able to understand the weather maps "very well", "How does the weather change? How does the weather change? How does the temperature change? How does the weather change? How does the temperature change?" Most of the students answered, "Now I can understand that.

An analysis of the students' misconceptions about weather revealed a lack of systematic learning in the field of meteorology and a lack of learning to answer wind direction from weather maps. (When students at a science university were asked to fill in the wind direction using the same weather map, the number of correct answers was 0/150 over six years.)

An analysis of the descriptions in the five textbooks used in Japanese junior high schools shows that weather maps are used, but wind direction is not studied in detail because the Coriolis force is considered to be a high school subject.

As a result, students do not understand the wind direction when they look at weather maps, and they do not understand that warm, moist air enters from the south of the front and generates cumulonimbus clouds. In addition, the diagrams in the textbook do not show clouds on the warm side of the front. This gives the wrong message that the south side of the front is the place where it will be sunny.

In reality, torrential rains often occur on the south side of the front.

An analysis of why textbooks include descriptions that differ from reality revealed that this is because they use models from a time when there were no meteorological satellite observations.

In order to improve this situation, it was found that learning to understand wind direction from weather maps and questions designed from misconceptions can provide effective learning about weather disaster prevention.

2.2 Questions for thinking about weather-related disasters

To these students who had learned to "read the wind," I asked them questions that I had considered through my misconception research.

A condition in which air rises are more likely to occur is called "unstable atmospheric conditions.

"Which is heavier, dry air or moist air? Which is heavier, dry air or moist air?

In response, most of the students answered that moist air is heavier.

This is one of the naive concepts, which leads to misconceptions.

If we study chemistry in high school and think in terms of molecular weight, we can understand that water vapour is lighter than nitrogen and oxygen, which are the main components of air.

When I tried this question in several university classes, almost everyone got it wrong.

So, after asking them to think about this question, I presented them with a case study as shown in Figure 3 (the forecast weather map for the July 2017 torrential rains in northern Kyushu, Japan).

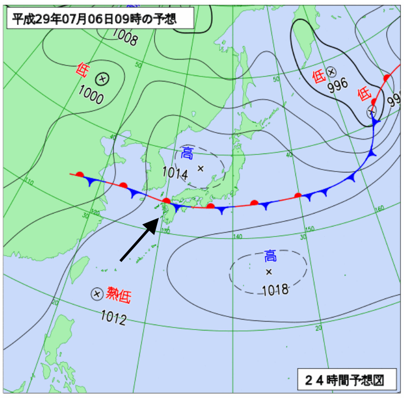

Figure 3 the forecast weather map for the July 2017 torrential rains in northern Kyushu, Japan

↗ Direction of inflow of warm and humid air

As a result, the students were able to better understand the situation where moist air is light, and cumulonimbus clouds develop when warm moisture inflow and dry air north of the front collide.

As in this case, students learn by asking questions based on misconceptions. It is then important to use this knowledge to learn about the causes of disasters such as heavy rain, strong winds, and lightning. When I taught college students the causes of heavy rain and other weather disasters using this method, they understood it very well.

In Japan, torrential rains often occur between June and September. The design presented here has proven to be very effective in helping us understand the forecast data provided by the Japan Meteorological Agency.

References [Arial, 12-point, bold, centred and with the first letter capitalized]

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