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Original Paper

Application of Bullseye Diagram in Teaching of "Variance"

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Abstract

Variance and standard deviation, as a kind of discrete function, are an important content in high school teaching, and they are widely used in data statistics. For high school students, they have difficulty understanding abstract concepts such as stability, volatility, and degree of dispersion when they are first exposed to discrete functions. In actual teaching, you can apply "bullseye chart" to "variance" teaching, and use abstract concept diagrams. Demonstration helps high school students to intuitively understand the concept of "variance" and the nature of dispersion.

Keywords

Variance, Discrete Function, Bullseye Diagram

1. Introduction

"Variance of discrete random variables" is an important teaching content in high school mathematics teaching. It is the basic knowledge of students contacting discrete functions and understanding data statistics. After entering the undergraduate level, We will learn relevant knowledge in depth, and apply the basic formula of variance in actual data statistics, especially in physics experiments, often use "variance" for data processing. How to deepen high school students' awareness of variance and further understand the meaning of dispersion is a question worth exploring.

2. Bullseye

The bullseye diagram is a graph composed of multiple concentric circles with radii, with a center point as the bullseye, as shown in Figure 1. Commonly found on bow and arrow targets, shooting targets, and dart targets. In shooting sports, the distance between the impact point and the bullseye can be used on the bullseye chart to judge the athlete's shooting accuracy. This is similar to the relationship between the variance in the discrete function and the center value (the average of the set of data). Bullseye chart

is widely used in the field of medical analysis, geological survey field, etc.

This article introduces bullseye diagarm into "variance" teaching. In the mathematical expression formula of variance, the center value (the average of the set of data) can represent the bullseye in the target, and the variance results calculated by different sets of data can be represented as the impact point of each shot on the target map. The distance between the impact point and the bullseye is used to indicate the fluctuation of this group of values: the greater the variance, the farther from the bullseye, the greater the volatility of the data and the more unstable it is, as shown in Figure 1.

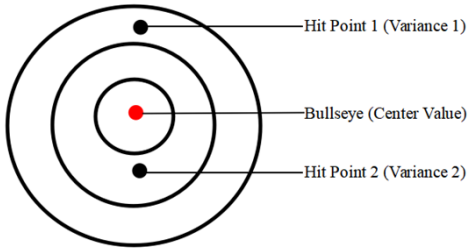

Figure 1. Example of Bullseye Diagram

The concept of "degree of dispersion" is relatively abstract and difficult to understand for high school students [5]. In Figure 1, you can intuitively see that the impact point 1 is closer to the bullseye, more stable, and less discrete. For students' understanding, it is more intuitive to compare which point is closer to the bullseye in a graphical way, which can achieve a clear result, which is helpful for students to understand the abstract concept of "dispersion" and the teacher's "variance" teaching.

3. Teaching Application Examples

In the high school teaching content "Variance of Discrete Random Variables", a classic topic- "Who is more appropriate to participate in a shooting competition?" the analysis of teaching application examples. Now there are two shooters participating in the selection. Their five shooting results are shown in Table 1:

Table 1. Shooting Results of Two Shooters

A's shooting results	B's shooting results
7	10
8	6
8	10
8	6
9	8

Question: (1) Please calculate the average scores of two contestants separately?

(2) Now we are going to select a player to participate in the competition. If you are a coach, which player do you think is more appropriate? Please tell why?

This classic example question can be described as a "linkage", which not only reviews the averages learned before, but also introduces students' thinking on new problems, and then introduces the new concept of "variance" in a timely manner [6]. In this example question, the students can find through the calculation of the first question that the average scores of the two contestants are the same, see equations (1) and (2):

$$M_{(A)} = \frac{7+8+8+8+9}{5} = 8 \tag{1}$$

$$M_{(B)} = \frac{10+6+10+6+8}{5} = 8 \tag{2}$$

On the bullseye diagram, it means that the two points A and B coincide at the bullseye, which cannot be distinguished from the bullseye chart, as shown in Figure 2. Since it is impossible to choose who is more suitable to participate in the competition from the perspective of the average (central value), the concept of "variance" can be introduced, and the nature of variance can be used to compare the stability of the two sets of data and whose variance is The smaller the calculation result, the more stable the performance, the smaller the volatility of shooting performance, and the further selection of who is more suitable to participate in the competition.

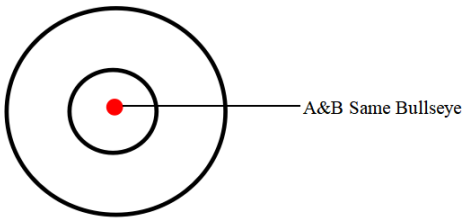

Figure 2. A&B Are the Same Bullseye

Variance is a data that can compare the deviation of each value from the central value of this group of values. Its calculation formula can be expressed as formula (3):

$$S^2 = \frac{(x_1 - M)^2 + (x_2 - M)^2 + \ldots + (x_n - M)^2}{n} \tag{3}$$

In this sample question, our standard for choosing a player is the one with more stable performance and less fluctuation in shooting performance. We need to ask for the variance of the shooting results of the two players, and then compare them with the bullseye chart. The variances of the shooting results of the two players are Equation (4) and Equation (5):

$$S_A^2 = \frac{(7-8)^2 + (8-8)^2 + (8-8)^2 + (8-8)^2 + (9-8)^2}{5} = 0.4 \quad (4)$$

$$S_B^2 = \frac{(10-8)^2 + (6-8)^2 + (10-8)^2 + (6-8)^2 + (8-8)^2}{5} = 3.2 \quad (5)$$

After calculating the variance of the shooting results of the two players, it is shown on the bullseye diagram as Figure 3: A is closer to the bullseye on the bullseye diagram, and his performance is more stable, so A should be selected to participate in the competition.

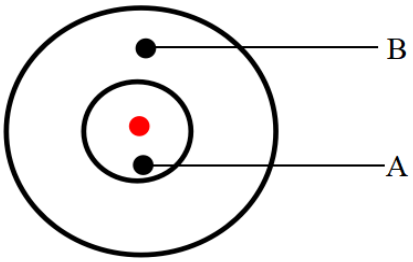

Figure 3. Distance between "Variance" and "Bullseye"

In the case analysis, there is a noteworthy application premise: the average value of each group of data needs to be equal, that is, to have the same bullseye, in order to use the bullseye chart to compare the stability between them. In the summary stage of the teaching content, teachers should guide students to analyze the prerequisites for the application of the bullseye diagram. If there is no same bullseye for each set of data, there will be no use of the bullseye diagram.

The advantage of introducing bullseye chart into "variance" teaching is that it is intuitive, concise and clear at a glance. Use the bullseye chart to explain the abstract concept of dispersion in variance, so that students are more intuitive and easy to understand. Using the example question of shooting target diagram of selected contestants, students are exposed to the two unfamiliar concepts of variance and discrete function. For students, starting from the common sense of shooting target, that is, the closer the target is to the bullseye, guide students and teachers to think about how to work together. The question of choosing contestants. In the variance, the central value (average value) can be easily understood as the bullseye in the target chart. The shooting data of each player can be represented by a target point, and the criteria for selecting contestants can be determined by the distance between the shooting point and the bullseye. Here, we use the daily target shooting and the "bullsseye diagram" of variance to be linked, to guide students to make associations to understand the degree of dispersion of variance representation, and it is also easier to understand the abstract concepts of volatility and stability.

4. Advantages and Improvements

Advantage 1: Use the bullseye graph method to explain the abstract concept of dispersion in variance, which makes students more intuitive and easy to understand. Using the example question of shooting

target diagram of selected contestants, students are exposed to the two unfamiliar concepts of variance and discrete function. For students, starting from the common sense of shooting target, that is, the closer the target is to the bullseye, guide students and teachers to think about how to work together. The question of choosing contestants. In the variance, the central value (average value) can be easily understood as the bull's-eye in the target chart. The shooting data of each player can be represented by a target point, and the criteria for selecting contestants can be determined by the distance between the shooting point and the bullseye. Here, we use the daily target shooting and the "bullseye diagram" of variance to be linked, to guide students to make associations to understand the degree of dispersion of variance representation, and it is also easier to understand the abstract concepts of volatility and stability.

Advantage 2: Incorporate part of the statistical knowledge at the undergraduate level into the variance explanation of the high school, so that students have a preliminary understanding of the discrete function, and at the same time have a distinction between the overall variance and the sample variance, which is more conducive to the students to learn statistics-related knowledge and connect with the beginning high school has the effect of analogy. In the process of explaining variance in the high school stage, the method of most teachers is to avoid and ignore why the variance is the sum of the squares of the difference between each value and the mean, or it is a rule, otherwise what is the variance of "variance", To a large extent limits the thinking of students, and also isolates the statistical knowledge learned at the undergraduate level from the knowledge of variance and standard deviation learned at the high school level. Variance is a kind of discrete function. Why is expressed by the mathematical formula of "square of difference" is not only determined by its name, but mainly by its discrete nature. First, the square can play the role of taking the absolute value, and the second is to prevent the addition of positive and negative from canceling the dispersion trend. On the contrary, the square root can better expand the degree of dispersion and make it easier for us to see in the final comparison. Degree of dispersion and stability. These knowledge points are conveyed to students in the way of thinking questions, which is more conducive to students' active thinking, and also helps to connect high school and undergraduate related knowledge teaching, rather than simply dividing them into two, purely for examination needs.

Improvements: Although this "bullseye diagram" teaching method of explaining variance is more intuitive and easy to understand, it also requires the cooperation and active exploration of students to achieve actual teaching effects, especially the part of thinking about the connection with the undergraduate stage. However, to convey the knowledge explained at the undergraduate level to high school students in the way of thinking questions, the students' understanding and acceptance is a question that has to be considered. "Bullseye" is a teaching method based on the connection between high school and undergraduate. Whether it fits the students' knowledge base and comprehension ability in specific teaching, and whether it can play a role in the connection of undergraduate level is still unknown. It also need practice, verify, and improve in future teaching work!

5. Discussion

Visualizing and intuitive content can not only attract students' interest in learning, but also deepen students' understanding and impression. Teachers need to constantly explore the content that can be intuitively taught in teaching, and present it to students in a clearer and concise way. At the same time, strengthen the connection between teaching content and life, turn abstract concepts into actual life, and present a more exciting class for students!

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