PRINCIPLES OF IMPROVING STUDENTS' PROBLEM-SOLVING SKILLS IN THE FIELD OF PROBABILITY THEORY

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ABSTRACT

This article discusses the principles for further developing and improving students' problem-solving skills in practical work on probability theory. Applying these principles is presented in the framework of the topic "Solving problems on the formula of absolute probability" with the solution of several problems.

Keywords: Probability calculation, absolute probability formula, polynomial formula, independent events, complete group of events, teaching.

INTRODUCTION

As we all know, the methods of probability theory are widely used in various fields of science and technology: reliability theory, theory of public services, theoretical physics, geodesy, astronomy, shooting theory, theory of automatic control, as well as in economics, medicine, etc. [1].

Probability theory also serves to substantiate mathematical and applied statistics, which, in turn, are used in production planning and organization, process analysis, product quality control and acceptance control, and for many other purposes. All this requires that the process of teaching probability theory in higher education institutions should be perfectly organized.

As in other disciplines, there may be various errors and omissions in the teaching of probability theory by professors and students. In particular:
- Lack of coherence in the sequence of topics and concepts;
- Incomplete coverage of the topic during the lessons;
- Classes are mainly limited to standard issues;
- Lack of real-life analogies of concepts on the subject;
- Delay of students in independent work;
- Insufficient methodological guidelines for science;
- Low attractiveness of the lesson;
- Lack of development examples and issues, etc.

This article sets out the principles of further development and improvement of students' problem-solving skills in practical work on the theory of probability, and also presents solutions to a number of problems using these principles in the context of "Problem solving by the probability formula".

Main Part

The following principles should be followed in order to further develop and improve students' problem-solving skills in the field of probability theory. [3,4,5,11,13]:

- Classroom equipment and organizational and methodological and teaching materials of the faculty should be ready for the training, and students should have fully mastered the theoretical knowledge and skills required for the practical training.
- After the development of individual issues for each topic, it is necessary to link them to the previous topics and draw conclusions from them. This is not only necessary to reinforce current and past topics, but also embodies the importance and relevance of science.
- Problems should be described not only in mathematical terms, but also in real-life, using objects and terms. At the same time, students realize that the problems are actually aimed at solving problematic situations in nature and society, in life, understand the essence of the problem, and as a result, their interest in this science increases.
- Problems should be solved not only by applying the concepts, theorems and assertions of the subject, but also by the concepts of other disciplines. At the same time, students understand that science is related to other disciplines, the range of logical thinking expands and intuitive approaches increase.
- topics should be selected or structured from topics that are as close or interesting to students 'lives and lives as possible. The choice of such topics will definitely keep each student alert and will motivate them to focus on the lesson.

Here are some examples of how to apply the above principles in a hands-on activity on "Solving Problems on the Formula of Absolute Probability". Before that, let's recall some important formulas.

Absolute probability formula [1,2,7,9,12]. Let us be interested in a random experiment. Let the elementary event space of this experiment be Ω. Suppose that the probability of an event B relating to this experiment is found. The events $A_i \in \Omega, i = \overline{1,n}, n \in N$ in this experiment should not be in pairs and form a complete group, ie:

1. $A_i A_j = \emptyset, i \neq j$;
2. $\bigcup_{i=1}^{n} A_i = \Omega$.

In that case $P(B) = \sum_{i=1}^{n} P(A_i) P_{A_i}(B)$.

Polynomial formula. $F_i, i = \overline{1,k}, k \in N$ events should not be in pairs and form a complete group, ie:

1. $P(F_i F_j) = 0, i \neq j$;
2. $\sum_{i=1}^{k} P\,(A_i) = 1$.

$p_i = P(F_i)$ Let's define as.

Let only one of the above k events occur in each of the n independent tests. Such a scheme is called a polynomial scheme.

In a polynomial scheme, the probability of occurrence of F_1 event m_1 times, F_2 event m_2 times, etc. F_k event m_k times is calculated as follows: $P_n(m_1, m_2, \dots, m_k) = \frac{n!}{m_1! \cdot m_2! \cdot \dots \cdot m_k!} \cdot p_1^{m_1} \cdot p_2^{m_2} \cdot \dots \cdot p_k^{m_k}$

here $0 \leq m_k \leq n, \sum_1^k m_k = n$.

Question, The criminal investigation department received a report of a crime. The probability of being in Zone 1 is 0.7, and the probability of being in Zone 2 is 0.3. The department has 8 operatives, each of whom works independently, and the probability of finding each culprit is 0.4. How should staff be distributed across regions to maximize the chances of finding a culprit? What is the probability of finding the culprit when the search is optimally organized?

Solution: Divide n employees into Zone 1 and $8 - n$ into Zone 2 to find the culprit $0 \leq n \leq 8$.

B – finding the culprit of the incident.

We identify the following events that do not occur in pairs and form a complete group:

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A_1 – the offender is in Zone 1;

A_2 – the offender is in Zone 2.

As you know, $P(A_1) = 0{,}7,\ P(A_2) = 0{,}3$.

If n employees are assigned to Zone 1, the probability that a criminal will be found in that area means that at least one of those n employees will be found. This is the opposite of the case where none of the n employees can find the culprit. So, $P_{A_1}(B) = 1 - 0{,}6^n$.

It's the same $P_{A_2}(B) = 1 - 0{,}6^{8-n}$. Now we find the probability of event B:

$P(B) = P(A_1)P_{A_1}(B) + P(A_2)P_{A_2}(B) = 0{,}7 \cdot (1 - 0{,}6^n) + 0{,}3 \cdot (1 - 0{,}6^{8-n}) =$

$= 1 - 0{,}7 \cdot 0{,}6^n + 0{,}3 \cdot 0{,}6^{8-n}$.

Under the condition of the problem, we need to find the value of n which reaches the maximum value of the probability of event B. If we consider the probability $P(B)$as a function of n, we find that the function takes the product of the function to find the maximum value of n and reaches the maximum value at the value found equal to zero:

$$(1 - 0{,}7 \cdot 0{,}6^n + 0{,}3 \cdot 0{,}6^{8-n})' =$$

$$= -0{,}7 \cdot 0{,}6^n \cdot ln0{,}6 + 0{,}3 \cdot 0{,}6^{8-n} \cdot ln0{,}6 = 0,$$

$$0{,}3 \cdot 0{,}6^n = 0{,}7 \cdot 0{,}6^{8-n}, \quad \frac{3}{7} = 0{,}6^{2n-8}, \quad n = \frac{log_{0,6}\frac{3}{7} + 8}{2} \approx 5.$$

This means that the probability of finding a criminal is highest when 5 people are assigned to Zone 1 and 3 people are assigned to Zone 2.

$$P(B) = 1 - 0{,}7 \cdot 0{,}6^5 + 0{,}3 \cdot 0{,}6^3 \approx 0{,}88$$

would be equal to

Answer: 5 people in Zone 1 and 3 people in Zone 2, $P \approx 0{,}88$.

Question, The teams in the Spanish Football Championship play 38 rounds. In the 34th round, Real Madrid is 4 points ahead of Barcelona. Real Madrid has a 0.8 chance of winning, a 0.1 draw and a 0.1 chance of losing in each of the following rounds. The same is true for the Barcelona football team. Find out if Barcelona can beat Real Madrid to win the championship.

Note: The two teams have already played each other. The winning team is awarded 3 points and the losing team is awarded 0 points. If recorded during, then both teams will be awarded 1 point. It has become clear that the team in third place will not be able to catch up with these teams. If both teams have the same number of points after the last round, Real Madrid will be the champions.

Solution: In each of the last 4 rounds, each team can either win (F_1 event), or draw (F_2 event), or lose (F_3 event). These events do not coexist in pairs and form a complete group. The corresponding probabilities are $p_1 = 0{,}8, p_2 = 0{,}1, p_3 = 0{,}1$. In the last 4 rounds, teams can score only one of the points 0,1,2,3,4,5,6,7,8,9,10,12. We define them as follows:

A_1 *– the team scored 0 points in the remaining 4 rounds (ie lost in all 4 rounds);*

A_2 *– the team scores 1 point in the remaining 4 rounds (ie draws in only one of the 4 rounds and loses in the remaining rounds);*

A_3 *– the team scores 2 points in the remaining 4 rounds (ie draws in only 2 of the 4 rounds and loses in the remaining rounds);*

A_4 *– the team scores 3 points in the remaining 4 rounds (i.e., loses only 1 of the 4 rounds in a winning round, or loses in 1 round by drawing 3 rounds);*

A_5 *– the team scores 4 points in the remaining 4 rounds (ie 1 win in 4 rounds, 1 draw in 2 rounds and 2 draws in 4 rounds);*

A_6 *– the team scores 5 points in the remaining 4 rounds (ie 1 win in 4 rounds, 2 draws and 1 loss);*

A_7 – *the team scores 6 points in the remaining 4 rounds (i.e. 2 wins in 4 rounds and 2 losses in 1 round or 1 draw in 3 rounds);*

A_8 – *the team scores 7 points in the remaining 4 rounds (ie wins 2 of 4 rounds, draws 1 and loses 1);*

A_9 – *the team scores 8 points in the remaining 4 rounds (ie 2 wins in 4 rounds and 2 draws);*

A_{10} – *the team scored 9 points in the remaining 4 rounds (ie won 3 of 4 rounds and lost 1);*

A_{11} - *The team scores 10 points in the remaining 4 rounds (ie wins 3 of 4 rounds and draws 1);*

A_{12} – *the team scores 12 points in the remaining 4 rounds (i.e. wins all 4 rounds).*

We calculate the probability of these events using the polynomial formula:

$P(A_1) = \mathrm{P}_4(0{,}0{,}4) = \frac{4!}{0!\cdot 0!\cdot 4!}\cdot 0{,}8^0\cdot 0{,}1^0\cdot 0{,}1^4 = 0{,}0001;$

$P(A_2) = \mathrm{P}_4(0{,}1{,}3) = \frac{4!}{0!\cdot 1!\cdot 3!}\cdot 0{,}8^0\cdot 0{,}1^1\cdot 0{,}1^3 = 0{,}0004;$

$P(A_3) = \mathrm{P}_4(0{,}2{,}2) = \frac{4!}{0!\cdot 2!\cdot 2!}\cdot 0{,}8^0\cdot 0{,}1^2\cdot 0{,}1^2 = 0{,}0006;$

$P(A_4) = \mathrm{P}_4(1{,}0{,}3)+\mathrm{P}_4(0{,}3{,}1) = \frac{4!}{1!\cdot 0!\cdot 3!}\cdot 0{,}8^1\cdot 0{,}1^0\cdot 0{,}1^3 + \frac{4!}{0!\cdot 3!\cdot 1!}\cdot 0{,}8^0\cdot 0{,}1^3\cdot 0{,}1^1 = 0{,}0036;$

$P(A_5) = \mathrm{P}_4(1{,}1{,}2)+\mathrm{P}_4(0{,}4{,}0) = \frac{4!}{1!\cdot 1!\cdot 2!}\cdot 0{,}8^1\cdot 0{,}1^1\cdot 0{,}1^2 + \frac{4!}{0!\cdot 4!\cdot 0!}\cdot 0{,}8^0\cdot 0{,}1^4\cdot 0{,}1^0 = 0{,}0097;$

$P(A_6) = \mathrm{P}_4(1{,}2{,}1) = \frac{4!}{1!\cdot 2!\cdot 1!}\cdot 0{,}8^1\cdot 0{,}1^2\cdot 0{,}1^1 = 0{,}0096;$

$P(A_7) = \mathrm{P}_4(2{,}0{,}2)+\mathrm{P}_4(1{,}3{,}0) = \frac{4!}{2!\cdot 0!\cdot 2!}\cdot 0{,}8^2\cdot 0{,}1^0\cdot 0{,}1^2 + \frac{4!}{1!\cdot 3!\cdot 0!}\cdot 0{,}8^1\cdot 0{,}1^3\cdot 0{,}1^0 = 0{,}0416;$

$P(A_8) = \mathrm{P}_4(2{,}1{,}1) = \frac{4!}{2!\cdot 1!\cdot 1!}\cdot 0{,}8^2\cdot 0{,}1^1\cdot 0{,}1^1 = 0{,}0768;$

$P(A_9) = \mathrm{P}_4(2{,}2{,}0) = \frac{4!}{2!\cdot 2!\cdot 0!}\cdot 0{,}8^2\cdot 0{,}1^2\cdot 0{,}1^0 = 0{,}0384;$

$P(A_{10}) = \mathrm{P}_4(3{,}0{,}1) = \frac{4!}{3!\cdot 0!\cdot 1!}\cdot 0{,}8^3\cdot 0{,}1^0\cdot 0{,}1^1 = 0{,}2048;$

$P(A_{11}) = \mathrm{P}_4(3{,}1{,}0) = \frac{4!}{3!\cdot 1!\cdot 0!}\cdot 0{,}8^3\cdot 0{,}1^1\cdot 0{,}1^0 = 0{,}2048;$

$P(A_{12}) = \mathrm{P}_4(4{,}0{,}0) = \frac{4!}{4!\cdot 0!\cdot 0!}\cdot 0{,}8^4\cdot 0{,}1^0\cdot 0{,}1^0 = 0{,}4096;$

Check: $0{,}0001 + 0{,}0004 + 0{,}0006 + 0{,}0036 + 0{,}0097 + 0{,}0096 + 0{,}0416 + 0{,}0768 + 0{,}0384 + 0{,}2048 + 0{,}2048 + 0{,}4096 = 1.$

Let's find the probability that Barcelona will win the championship by marking it with B. *Understandably, in order for Barcelona to win the title, they need to score at least 5 points more than Real Madrid. Therefore, we first calculate the conditional probabilities.*$P_{A_i}(B), i = \overline{1{,}12}$.

$P_{A_1}(B) = P(A_6) + P(A_7) + P(A_8) + P(A_9) + P(A_{10}) + P(A_{11}) + P(A_{12}) = 0{,}0096 + 0{,}0416 + 0{,}0768 + 0{,}0384 + 0{,}2048 + 0{,}2048 + 0{,}4096 = 0{,}9856;$

$P_{A_2}(B) = P(A_7) + P(A_8) + P(A_9) + P(A_{10}) + P(A_{11}) + P(A_{12}) = 0{,}0416 + 0{,}0768 + 0{,}0384 + 0{,}2048 + 0{,}2048 + 0{,}4096 = 0{,}976;$

$P_{A_3}(B) = P(A_8) + P(A_9) + P(A_{10}) + P(A_{11}) + P(A_{12}) = 0{,}0768 + 0{,}0384 + 0{,}2048 + 0{,}2048 + 0{,}4096 = 0{,}9344;$

$P_{A_4}(B) = P(A_9) + P(A_{10}) + P(A_{11}) + P(A_{12}) = 0{,}0384 + 0{,}2048 + 0{,}2048 + 0{,}4096 = 0{,}8576;$

$P_{A_5}(B) = P(A_{10}) + P(A_{11}) + P(A_{12}) = 0{,}2048 + 0{,}2048 + 0{,}4096 = 0{,}8192;$

$P_{A_6}(B) = P(A_{11}) + P(A_{12}) = 0{,}2048 + 0{,}4096 = 0{,}6144;$

$P_{A_7}(B) = P(A_{12}) = 0{,}4096;$

$P_{A_8}(B) = P(A_{12}) = 0{,}4096;$

$P_{A_9}(B) = P_{A_{10}}(B) = P_{A_{11}}(B) = P_{A_{12}}(B) = 0.$

$P(B)$ We calculate using the formula of absolute probability:

$P(B) = \sum_{i=1}^{12} P(A_i) \cdot P_{A_i}(B) = 0{,}0001 \cdot 0{,}9856 + 0{,}0004 \cdot 0{,}976 + 0{,}0006 \cdot 0{,}9344 + 0{,}0036 \cdot 0{,}8576 + 0{,}0097 \cdot 0{,}8192 + 0{,}0096 \cdot 0{,}6144 + 0{,}0416 \cdot 0{,}4096 + 0{,}0768 \cdot 0{,}4096 = 0{,}06647808.$

This means that at the end of the championship, the probability of Barcelona winning the championship after overtaking Real Madrid is $0{,}06647808$.

Answer: $0{,}06647808$.

Question, The letters T, U, L, A, N, M, I, R, Z, A are written on the 10 balls in the first box, and the letters N, I, S, H, O, N, O, V are written on the 8 balls in the second box. 3 balls were randomly taken from the first box and placed in the second box. Then find the probability that it is possible to create a ROMAN record from the letters on the 5 balls randomly taken from the second box.

Solution: Experiment - the letters T, U, L, A, N, M, I, R, Z, A on the 10 balls in the first box, and the letters N, I, S, H, O, N, O, V on the 8 balls in the second box 3 balls are randomly taken from the first box and placed in the second box, and then 5 balls are randomly taken from the second box.

B – It is possible to create a ZAMON notation from the letters on the 5 balls from which the event took place.

The balloons in the second box contain the letters O and N of the word ROMAN. This means that event B can only be expected when balloons with the letters R, M and A are taken from the first box, otherwise event B does not occur..

When 3 balls are randomly taken from the first box and placed in the second box, the total number of possible elementary results is C_{10}^3, and we can divide them into random events that do not exist in pairs and form a complete group. Only in the case of these random events, in which only the letters R, M, and A are obtained, under the condition of this event, the conditional probability of event B assumes a value different from 0, otherwise it is equal to 0. If we denote the same event by A, then$P(A) = \frac{C_1^1 C_1^1 C_2^1 C_6^0}{C_{10}^3} = \frac{2}{120} = \frac{1}{60}$.

Now let's calculate the conditional probability $P_A(B)$. If an event occurs, then the second box contains 11 balls with the letters N, I, S, H, O, N, O, V, R, M, A. When 5 balls are randomly taken out of the box, we find the probability of the event of the balls coming out with the letters R, O, M, A, N:

$P_A(B) = \frac{C_1^1 C_2^1 C_1^1 C_1^1 C_2^1 C_4^0}{C_{11}^5} = \frac{4}{462} = \frac{2}{231}$.

Finally, we find the probability of event B:

$P(B) = P(A)P_A(B) = \frac{1}{60} \cdot \frac{2}{231} = \frac{1}{6930}$.

Answer: $\frac{1}{6930}$.

Question, The young bride received a question from the groom: “Assalamu alaykum. We are Alan and Amanda. We will have children soon. My (Alan) blood type is third and my wife's is second. We know that the fourth blood group is the most scarce in the world. How likely is it that our unborn child will have a fourth blood type? ”

Solution: Let B denote the event that the unborn child has the fourth blood type. To solve this problem, let's first look at some basic facts about biology. It is known from biology that humans are divided into homozygous and heterozygous customers. According to genetic analysis, for people with the above blood groups, the chances of a child having a fourth blood type are as follows:

100% - if the parents are homozygous;
25% - if the parents are heterozygous;
50% - if the father is homozygous and the mother is heterozygous;
50% - if the father is heterozygous and the mother is homozygous.

Due to the lack of parental client information, the following events are considered equally likely:

A_1 - father and mother being homozygous;
A_2 - father and mother being heterozygous;
A_3 - father being homozygous, mother being heterozygous;
A_4 - the father is heterozygous and the mother is homozygous.

Understandably, $P(A_1) = P(A_2) = P(A_3) = P(A_4) = 0{,}25$, and $P_{A_1}(B) = 1, P_{A_2}(B) = 0{,}25, P_{A_3}(B) = 0{,}5, P_{A_4}(B) = 0{,}5$.

In that case, according to the formula of absolute probability:

$P(B) = P(A_1)P_{A_1}(B) + P(A_2)P_{A_2}(B) + P(A_3)P_{A_3}(B) + P(A_4)P_{A_4}(B) = 0{,}25 \cdot 1 + 0{,}25 \cdot 0{,}25 + 0{,}25 \cdot 0{,}5 + 0{,}25 \cdot 0{,}5 = 0{,}5625.$

Answer: Approximately 56%

Question, The coin is tossed three times in a row with the "emblem" side or twice in a row with the "coin" side. Find the probability that the coin toss ends with the "emblem" side falling three times. The probability of a coin falling with the "emblem" and "coin" sides is $\frac{1}{2}$, and the results of each coin are independent of each other [6].

Solution: The probability of a coin falling three times with the "emblem" side (GGG) under the condition that the coin falls with the "emblem" side (GG) twice is x, The probability that the coin will fall with the "emblem" and "coin" side (GT) is y, the probability that the coin falls with the coin and the emblem side (TG) is z. The probabilities of GG, GT, and TG events are $\frac{1}{4}$. After GG, there is a $\frac{1}{2}$probability that GGG or GGT events will occur. Under the GGT condition, the probability of GGG occurring was y. According to the formula of absolute probability $x = \frac{1}{2} \cdot 1 + \frac{1}{2} \cdot y$. Similar GTT or GTG events occur with a $\frac{1}{2}$ probability after GT. That is why $y = \frac{1}{2} \cdot 0 + \frac{1}{2} \cdot z$. TG after $\frac{1}{2}$ TGT or TGG events are likely to occur. That is why $z = \frac{1}{2} \cdot x + \frac{1}{2} \cdot y$. Solving the system of equations, $x = 0{,}6, y = 0{,}2, z = 0{,}4$ solutions. We also find the requested probability using the formula of absolute probability:$p = \frac{1}{4} \cdot 0{,}6 + \frac{1}{4} \cdot 0{,}2 + \frac{1}{4} \cdot 0{,}4 = 0{,}3$.

Answer: 0,3

The following issues, similar to the ones above, can be suggested to students to solve independently:

1. 25 tickets were prepared for the final control on the subject of probability theory. David prepared questions for 20 tickets. Students take turns entering the control and taking one ticket each and sitting in the auditorium to answer it. Was David more likely to get a ticket when he was the first to enter the checkpoint, or was he the second to enter?

2. Have each student write each letter of his or her name on each of the balloons in the first box, and the letters of his or her last name on each of the balloons in the second box. Take a few balls from the first box and put them in the second box, and then find the probability that when you take a few balls from the second box, you can form a meaningful word from the letters in it (see Problem 3, that is, each student uses his vocabulary. make and solve it).

3. If a competitor does not produce the same product, the probability that the product will be in the market is 0.67. If there is a competitive product in the market, it is probably 0.42. Find

the probability that a competing firm will be a buyer if the probability of a competing firm producing a competitive product during the observed period is 0.35 [2].

4. Ten helicopters have been set up to search for the missing plane. Each of them can search in one of two areas where the plane has a probability of 0.8 and 0.2. If for each helicopter the probability of finding an aircraft in the missing area is 0.2 and they search independently, how should the helicopters be distributed over the search areas to maximize the probability of finding the aircraft? What is the probability of finding the plane when the search is optimally organized?

5. The travel agency organizes summer trips to the Mediterranean and organizes several trips during the season. The competition is fierce in this type of business, so for the company to make a profit, all the cabins of the cruise ship must be occupied by tourists. A tourism expert hired by the company predicts that if the dollar does not rise against the soum, all cabins will be 0.92, or 0.75. If the probability of the dollar appreciating against the som is 0.23, find the probability that all travel tickets will be sold. [2]

CONCLUSION

The more students are given similar problems solved using the above principles, the better the student will master and consolidate the topics covered, understand the importance and relevance of the subject, expand the range of logical thinking and increase intuitive approaches, understand that the issues are actually aimed at solving problematic situations in nature and society, in life, understand the essence of the problem, and as a result, their interest in this science increases.

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