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# Evaluation of Prospective Mathematics Teachers' Opinions on Probability Lessons

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**Abstract:** One of the most difficult mathematical subjects to learn and teach today is the subject of probability. The review of the existing literature on the subject of teaching probability reveals that students struggle with several aspects of probability. One of the key findings of these studies is that challenges with teaching probability are faced not just by students, but also by prospective teachers and even teachers. Knowing prospective mathematics teachers' views on probability teachings, particularly the challenges they encounter, will be the first step in educating teachers who are well-equipped in probability. This study therefore aims to reveal the views of prospective mathematics teachers on probability subjects. The present study aims to reveal the views of prospective mathematics teachers on probability lessons. The study group consisted of 32 senior-year prospective teachers in the Elementary Mathematics Teacher Education Program of a state university in Türkiye. The participants were selected using the purposive sampling technique due to their enrollment in probability and statistics lessons at the university, which aligns with the study objectives. An open-ended questionnaire prepared by the researcher in line with expert opinions was used as a data collection tool. The data were analyzed by content analysis, one of the qualitative data analysis techniques. The data obtained from the documents in which prospective teachers answered the questions in writing were categorized under six categories: experience, lack of knowledge, difficulty of the subject, indifference of students, its impact on the profession, and solution suggestions. The findings of the study revealed that the prospective teachers continued the prejudices they had acquired during their primary and secondary education years at the university. Furthermore, they reported that these prejudices persisted even after they entered the profession. Since these prejudices of prospective teachers have negative effects on probability learning and teaching, probability lessons should be meticulously emphasized in teacher training. The fact that they limited probability to basic concepts, had taken a course on teaching probability and statistics, and did not mention these practices in written documents even though they could offer alternative solutions to the problems faced demonstrated that their prejudices were more dominant.

**Keywords:** Probability, Probability Teaching, Prospective Mathematics Teachers

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## 1. Introduction

Probability concepts are concepts that we commonly use in the decision-making process when faced with uncertainty in our daily lives. Probability has been integrated into mathematics curricula beginning with preschool and elementary education due to the importance and necessity of its usage in daily life and many business areas with the reform movements in mathematics education in many countries over the last two decades [1]. As it started to be included in mathematics curricula, various problems related to learning probability came to the agenda over time, as in other learning

areas. These problems are the subject of many studies in literature [1-5].

The review of the existing literature on the subject of teaching probability reveals that students struggle with several aspects of probability. One of the main reasons for these problems is students' misconceptions [1, 6-12]. These misconceptions were determined in the literature as representation, negative and positive recency effect, simple and compounds, representation shortcut, merger misconception, misconception of the effect of sample size, and conclusion approach [7, 13-14]. The second of the problems experienced by the students regarding probability

teaching is the inability to understand the subject of probability in general and the difficulties experienced in solving probability questions. The above problems can be seen as problems with how well students can connect probability concepts to real-world situations, how well they understand probability as a foundation, how language and intuition affect the development of probabilistic thinking, how well students can reason, and how they feel about probability [15-19]. When considering the various challenges associated with teaching probability, it becomes evident that probability is a particularly complex subject to comprehend. Furthermore, many alternative solutions have been suggested in the literature to solve the problems experienced in teaching probability [20-24]. One of the key findings of these studies is that challenges with teaching probability are faced not just by students, but also by prospective teachers and even teachers [25-28]. According to a report by the Conference Board of the Mathematical Sciences in the United States (CBMS, 2001), statistics and probability are the subjects for which teachers are most unprepared among mathematics subjects at the middle and high school levels. Minimizing the problems in probability teaching will only be possible by training qualified teachers in probability. Knowing prospective mathematics teachers' views on probability teachings, particularly the challenges they encounter, will be the first step in educating teachers who are well-equipped in probability. This study therefore aims to reveal the views of prospective mathematics teachers on probability subjects. The findings of this study are important in terms of contributing to the training of prospective mathematics teachers who are comfortable with probability. In this context, the problem of the research was determined as "What are your positive or negative opinions on probability? Discuss your experiences on the probability subject in detail."

## 2. Methodology

The qualitative research method, which aims to reveal the perceptions and experiences of participants, was employed in this study [29]. The current study aimed to reveal the perceptions and experiences of prospective mathematics teachers on the probability subject.

### 2.1. The Study Model

A case study design based on a qualitative research approach was used in this study. Qualitative case studies are studies that investigate one or more situations in depth with a comprehensive approach. These studies examine whether the factors related to the situation affect the situation and how it affects them [29]. This method was chosen since this study explored in-depth prospective teachers' experiences with the probability subject.

### 2.2. Study Group

The participants are 32 senior-year prospective teachers in the Elementary Mathematics Teacher Education Program of a

state university in Türkiye. The participants were determined using the purposive sampling method. The purposive sampling method allows for in-depth research by selecting circumstances that are rich in information, meet particular criteria, and have certain qualities based on the study's objective [29]. In order to obtain more information in accordance with the study's objective, participants were chosen from among those who had not only taken the probability subject at the university but also the teaching of probability and statistics course were senior students and voluntarily participated in the study. Prospective teachers studied the fundamental subjects of probability, axioms of probability, random variables and their types, and some discrete and continuous probability distributions in probability subjects. The probability and statistics course examined the teaching of probability simulations and probability distributions (organizing content, using appropriate teaching materials and strategies, etc.), student knowledge of these topics, and the relationship of these topics with daily life and other subjects. Codes such as P-1, P-2, etc. were used instead of the real names of the participants.

### 2.3. Data Collection

For data collection, the researcher developed an open-ended questionnaire based on expert opinions. Students were asked to write an essay expressing their opinions and thoughts on the probability subject, approaching the subject holistically, and focusing on a specific question. Therefore, they were able to convey naturally and sincerely whatever they wanted to write.

### 2.4. Data Analysis

The data were analyzed by content analysis, one of the qualitative data analysis techniques. The main purpose of content analysis is to reach concepts and relationships that will explain the obtained data. Content analysis can reach concepts and ideas that are not recognized by a descriptive technique. Data are conceptualized and logically structured, and themes that explain the data are recognized [29]. The researcher divided the data from this study into six categories. The answers were analyzed, and those with more than 60% were selected and analyzed. Student opinions were provided in enough numbers to represent the perspectives of nearly all of the participants in the study. This enables the reader to be familiar with the opinions of all participants. The data from the interviews were then examined to verify the accuracy of the data analysis, and any sections that were deemed to be outside the scope of the study were eliminated.

## 3. Findings

This section presents the conclusions gained through the content analysis approach of examining data from the opinions of prospective teachers who participated in the study. The answers given to the open-ended question posed to the prospective teachers in the study were used to develop six categories: experience, lack of knowledge, the difficulty of the

subject, the indifference of students, its impact on the profession, and solution suggestions. The categories were formed by transferring the opinions of the prospective teachers. Prospective teachers were named P-1, P-2, etc.

### 3.1. Experience

Prospective teachers' opinions of the subject were influenced by their prejudices about the probability subject they had taken in their previous education. The prejudices formed as a result of memorizing classical probability problems such as throwing dice, tossing money, and drawing marbles from a bag; giving incorrect answers when faced with a different question; and failing to achieve the desired success by memorizing the probability subject they had taken in middle and high school were carried over to the university. The opinions are as follows:

(P-27): *I have a prejudice towards probability. I did not get it in high school either. I memorized the questions because they were generally similar to each other, but I still made mistakes in the exams.*

(P-21): *The probability subject was taught based on memorization during my previous education. The order and manner in which we think are highly significant in probability, but up until now, we have tried to achieve things by memorizing.*

(P-17): *During elementary and high school, permutation-combination questions were within certain patterns that come to our minds when we think of probability. For example, despite frequent mentions, I was unable to grasp the relationship and distinction between permutation and combination. I am not sure I can understand it, yet I memorized it.*

(P-20): *Probability is not a particularly easy subject, but I struggled with it in high school and continue to struggle with it now. Even if I memorize all the questions, they get mixed up after a certain point because of my prejudices.*

(P-5): *Probability is one of the subjects that I have failed the most in my academic life so far. That is why I got a little prejudiced. Not that I do not like it, but I would say I am less interested because of the prejudice.*

### 3.2. Lack of Knowledge

The study revealed that prospective teachers tended to approach probability problems by employing metacognitive problem-solving strategies. However, it is important to highlight that they were unable to attain the needed degree of proficiency in solving such problems. Most of the students had issues understanding and analyzing the problem, while no student expressed their opinions in the stages of planning and exploring the problem and checking the accuracy of the answer. The opinions are as follows:

(P-6): *I regard myself as the main reason for my failure in probability. I have a really hard time understanding the questions in probability subjects. I think I will be successful in this subject if I understand the questions.*

(P-8): *I believe that to be able to solve probability questions,*

*we need to have the ability to understand the question first.*

(P-16): *Something is put in front of you: "... how many different ways can there be... how many ways can be chosen?" Then we start thinking, could permutation or combination solve this? However, if we can understand the question, we will have solved our problem, and we will be able to see whether permutation or combination is employed to answer the problem. In other words, our main problem is that we are not able to break our stereotyped thoughts out of those patterns and produce new schemas for ourselves.*

(P-22): *The probability questions are sometimes really challenging. However, the reason we are having difficulty with those questions is because of the misunderstandings we have gained thus far.*

(P-26): *Probability is a subject in which you must think about possibilities systematically. Firstly, rather than analyzing the question on the way to the solution, it is critical to correctly understand the problem and have a clear knowledge of what is being asked. The biggest factor that makes it difficult for me is my lack of knowledge. I do not know what to think about the question in front of me. After coping with my lack of knowledge, my concern is that I make mistakes in the concepts in the question. So, I am asking myself, "What is being asked?" since I do not fully comprehend the question. Following this question, I will attempt to develop a new perspective and devise a new answer. Of course, this raises a completely different question.*

(P-30): *I find it difficult to understand its logic because I feel like the probability of all possibilities should be  $\frac{1}{2}$ .*

### 3.3. The Difficulty of the Subject

Prospective teachers typically found the probability subject difficult because they had difficulty expressing the provided problem in mathematical language. The opinions are as follows:

(P-10): *I am interested in probability because it is related to daily life. Yet, in probability, I think that converting the question into numbers or formulizing it means that you achieve 70% of solving the question, but I am bad at it. Probability is a complex and difficult subject.*

(P-15): *Although I have solved many examples and studied the subject, I generally have difficulty solving the questions. When I read the question, it sounds easy, but when it comes to the operations, I get confused or I get missing data. I think my small mistakes affected the result.*

(P-11): *We have difficulty visualizing the questions in our minds while analyzing them. Yes, this is not true for all questions; but we experience these problems in most questions. One of the reasons for this is that we intertwine several operations. The wordplay in the question also makes it more difficult. Although we know something in some questions, we cannot express it in formulas.*

(P-4): *To understand probability, we must have both verbal and numerical skills.*

(P-23): *I think the reason this subject is difficult is that the problems have many different solutions. After finding the results, we do not know exactly how to express the result, that*

is, the formal relation.

(P-18): It is critical to understand the problem thoroughly, to grasp each sentence, to evaluate the arrangement of the words, and even the placement of a comma, and this makes it difficult for us to formulate.

### 3.4. Indifference of Students

Lack of motivation based on previous experiences, students' lack of self-confidence, low expectations, not giving the subject the necessary importance, not knowing the methods and techniques of studying, and deficiencies in basic education caused them to be indifferent to the probability. The opinions are as follows:

(P-24): In addition to the already difficult subjects, the content and problems of this subject are intellectually challenging, with some of them being impossible to solve, making it extremely difficult for us.

(P-7): I think about the curriculum and the way it is typically taught since middle and high school. That is why I do not understand, and I do not take it very seriously, honestly. I cannot have confidence in myself.

(P-3): The probability subject feels a little different from the other subjects because we can do other subjects with concrete thinking. It is not what I am interested in because we need to think more abstractly about probability.

(P-19): I have taboos against the probability subject. When I read the question, what comes to mind is a set of details. I get lost in so many details that I often cannot even move my pen to find a solution. However, of course, I also criticize myself: I am not trying hard enough.

(P-32): Preparing for their exams requires serious time. Seems like a useless endeavor.

### 3.5. Impact on the Profession

Considering the prejudices, lack of knowledge, and the difficulty of the subject, prospective teachers exhibited behavior that probability is as difficult to explain as it is to understand. The opinions are as follows:

(P-9): For me, this is a subject that is difficult for me to grasp and comprehend. So, I think it will be difficult to explain.

(P-32): I do not enjoy explaining it because I find it difficult to understand and think that I have failed.

(P-33): The topics in the subject have too many questions, and each question has a different solution. This is why it is a subject that I would not like to teach, and I would find it difficult.

(P-14): It is a subject that I will have difficulty teaching it. It is a subject that I have a lot of difficulty in my teaching life, so it can be a difficult teaching process for me.

### 3.6. Solution Suggestions

Prospective teachers proposed simplifying the subject, associating it with examples from daily life, and including theorem proofs in the tests. The opinions are as follows:

(P-1): We prefer to keep the content as simple as possible

and to provide the most useful parts of the subject.

(P-25): I thought I knew enough about the probability. However, as I proceeded with the lessons, I realized that my perspective was completely wrong. For example, while I used to believe that we could only perform combinations and permutations using formulas, I now recognize that these concepts are highly relevant to daily life and that the issues should be answered by tying them to daily life. The best example is that we will solve an issue by first employing a real-world model of the problem and then converting it into a mathematical model.

(P-12): I think proof of theorems should also be asked in class because being able to prove theorems requires students to have more knowledge about the subject. I think the exam questions should ask about the proofs of theorems.

## 4. Conclusion

Consequently, the findings of this study indicate that prospective teachers did not successfully overcome the prejudices they had developed during their primary and secondary education, and they still believe that prejudices would persist throughout their careers in the teaching profession. Their prejudices can be attributed to several factors. First, during their primary and secondary education, they tended to memorize the subject rather than fully comprehend it. Additionally, the informal language used in the question, coupled with the fact that each question was structured according to its language, further reinforced their existing prejudices. Therefore, they were unable to overcome the influence of these prejudices. Prospective teachers' prejudices negatively affected their lack of knowledge and motives for struggling with the subject. Furthermore, when it comes to probability, it was discovered that they limited it to the fundamental ideas taught in elementary and secondary school. Despite having significant experience using acceptable resources in probability education, no students suggested these materials as an alternate solution to the challenges they mentioned. This showed that their prejudices were more prevalent, highlighting the necessity for comprehensive research on probability education.

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