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USE OF DIGITAL TECHNOLOGIES IN TEACHING PROBABILITY THEORY (ON THE EXAMPLE OF PHET INTERACTIVE SIMULATIONS)

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Abstract:
This article discusses the importance of digital technology in our lives, the role of digitization in the reform of the education system, which programs can be used in teaching probability theory, and PhET interactive simulations.

Keywords: Probability theory, statistics, digital technologies, PhET interactive simulations, mobile applications, artificial intelligence.

Introduction

One of the priority areas for the development of the modern education system is the introduction of information technologies into the educational process. The use of digital technologies in educational activities is becoming a real practice. Currently, an educational environment has been created in which digital technologies can be used, and most teachers are successfully using it.

Digital technologies open up new, limitless opportunities for the teacher. When using these technologies, the demonstration of the possible vision becomes more successful.

The ability to independently work with a large amount of information located on many sites on the Internet and obtain new knowledge serves as the most important educational and methodological base for students.

ANALYSIS AND RESULTS

Using digital technologies in teaching probability theory can greatly enhance the learning experience by providing interactive, engaging, and accessible ways to

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explore complex concepts. Here are some effective methods and tools for incorporating digital technologies into teaching probability theory:

1. Interactive Simulations and Visualizations

- **Tools like GeoGebra and Desmos**: These platforms allow students to visually explore probability concepts. For example, students can simulate coin tosses, dice rolls, or random selections to visualize the law of large numbers or the central limit theorem.

- **PhET Interactive Simulations**: Developed by the University of Colorado, these simulations offer engaging interactive experiences for teaching probability concepts such as random events, dice rolls, and probability distributions.

- **Wolfram Mathematica**: This can be used for more advanced simulations and to create probability distributions, random variables, and more complex visualizations.

2. Online Probability Simulators and Tools

- **Simulation-based learning tools** like "Probability Simulator" or "CensusAtSchool" allow students to conduct experiments, test hypotheses, and observe outcomes of random events. These tools help in visualizing probability distributions and understanding how probability works in real-life scenarios.

- **R or Python (with libraries like NumPy, Pandas, and Matplotlib)**: These programming languages can help students perform Monte Carlo simulations, visualize distributions, and calculate probabilities using data-driven methods.

3. Gamification

- **Interactive Games**: Games such as "The Game of Life" or "Roulette" simulations can help students understand random events, probabilities, and statistics in a fun and interactive way. Websites like Kahoot and Quizlet can be used to create probability-themed quizzes that promote engagement.

- **Serious Games**: Platforms like **Mathematical Mondays** offer game-based learning around probability theory, where students can apply concepts in real-world simulations.

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4. Learning Management Systems (LMS) with Interactive Content

- **Moodle, Canvas, or Google Classroom**: These LMS platforms support integration with tools like quizzes, video lectures, and discussions, where instructors can upload multimedia content explaining probability theory and then have students complete simulations, assignments, and collaborative activities.

- **H5P Interactive Content**: This can be used to create interactive quizzes, timelines, simulations, and other educational content related to probability theory.

5. Data Analysis Software

- **Excel, Google Sheets, or SPSS**: Students can use these tools for analyzing data, calculating probabilities, working with statistical distributions, and visualizing the results. Using datasets, students can compute experimental probabilities and compare them with theoretical predictions.

- **Python for Data Science**: Python, particularly with libraries like SciPy and Matplotlib, allows students to work with real-world datasets and apply probability theory in various contexts, such as hypothesis testing, regression analysis, or Bayesian methods.

6. Virtual Reality (VR) and Augmented Reality (AR)

- **AR/VR-based Apps**: These can immerse students in environments where they can interact with probability scenarios. For instance, students could engage in VR simulations of random events (such as tossing balls into bins or drawing cards from a deck) to better understand probability distributions or the law of total probability.

- **Google Cardboard or Oculus**: Simple VR platforms can be used to experience probability concepts in a highly engaging, visual manner.

7. Collaborative Tools

- **Padlet, Miro, or Jamboard**: These platforms can be used for brainstorming, problem-solving, and collaborative learning. Students can work together to solve probability problems, share results of simulations, and discuss interpretations of probability concepts.

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- **GitHub**: For more advanced students, GitHub can be used to share code related to probability experiments, Monte Carlo simulations, and other technical aspects of probability theory.

8. Online Courses and MOOCs

- **Coursera, edX, or Khan Academy**: These platforms offer interactive courses that teach probability theory, many of which incorporate videos, quizzes, peer interactions, and hands-on coding exercises (often in Python, R, or MATLAB).

- **Interactive Textbooks**: Some digital textbooks allow students to work through interactive examples that let them visualize and test various probability concepts in real time.

9. Visualization of Probability Distributions

- **Tableau or Power BI**: These visualization tools can help students visualize different types of probability distributions (like normal, binomial, Poisson) and how parameters change the shapes of distributions.

- **Statistical Graphing Tools**: Students can use tools like **Matplotlib** in Python to plot probability distributions and gain insights from the visual representation.

10. AI-Based Tutoring Systems

- **Chatbots or AI Tutors**: Using tools like **Socratic** or **ChatGPT**, students can ask specific questions about probability theory, and these AI tools can provide tailored explanations, hints, and even step-by-step solutions to complex probability problems.

11. Real-World Applications and Case Studies

- **Big Data & Probability**: Instructors can teach students how probability theory applies to fields such as artificial intelligence, machine learning, insurance, and epidemiology by using real-world datasets and case studies. Websites like Kaggle offer datasets for students to practice their probability and statistical skills.

Let's review the general steps for using PhET simulations:

PhET Interactive Simulations is a suite of online simulations developed by the University of Colorado that provides interactive tools for students to learn about

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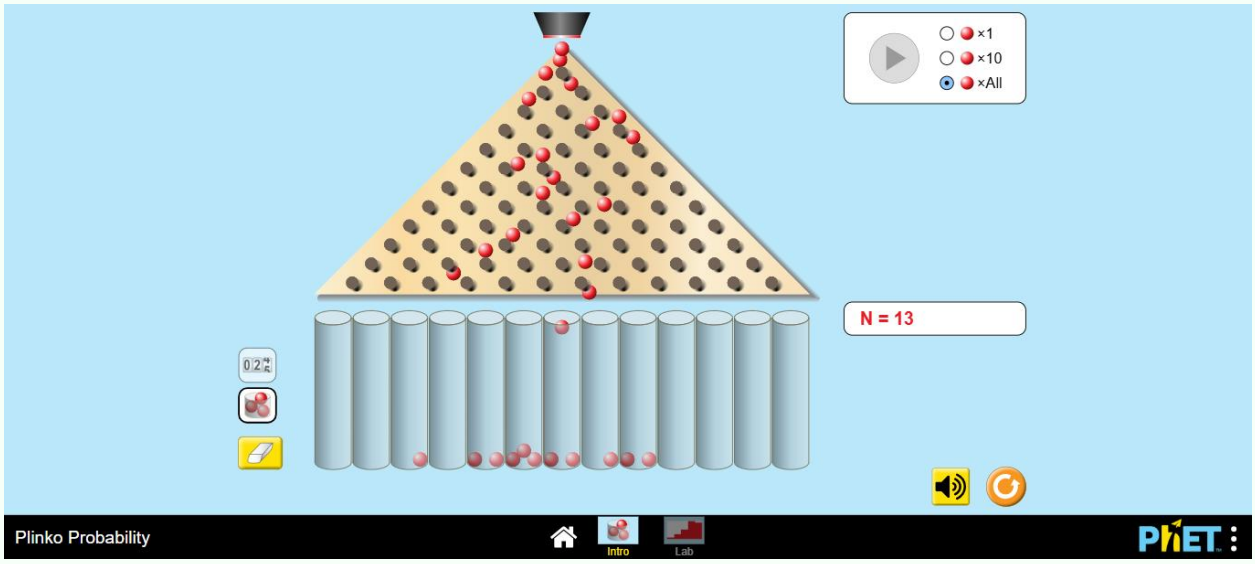
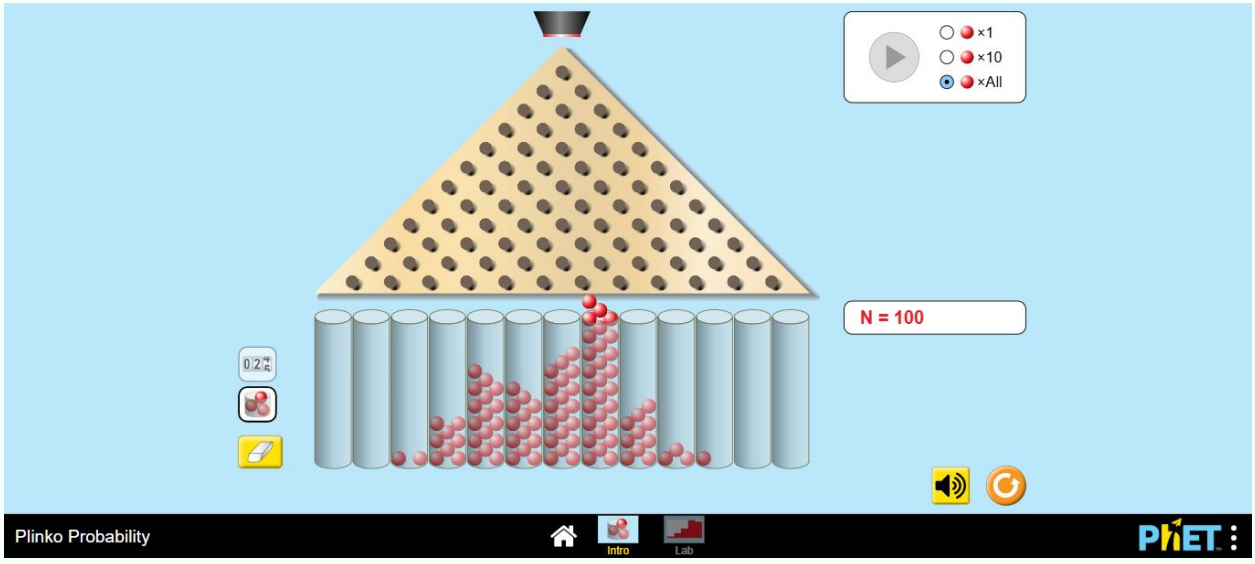
a variety of subjects (including mathematics, physics, chemistry, and biology). PhET simulations can also be used to teach probability theory and statistics.

Example

• Imagine a box into which a single ball can fall.
• Repeat the 100 ball trial and compare the results.
• Count the number of balls in the box and relate it to the probability of falling into that box.
• Compare and interpret empirical and theoretical statistics.

The program's introduction provides an opportunity to explain how to perform the experiment and to review the results of the trial.





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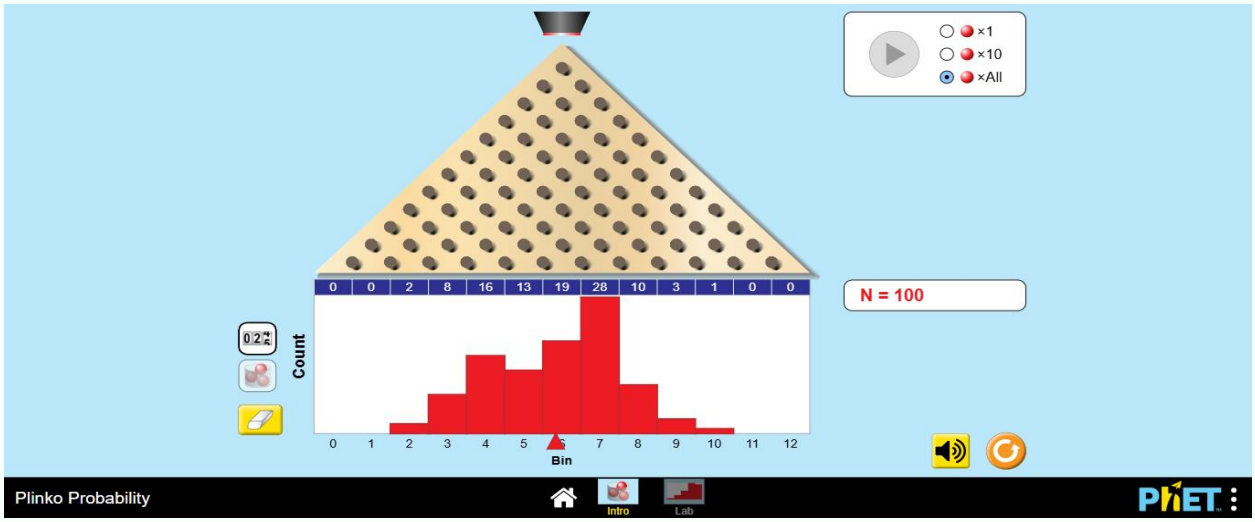
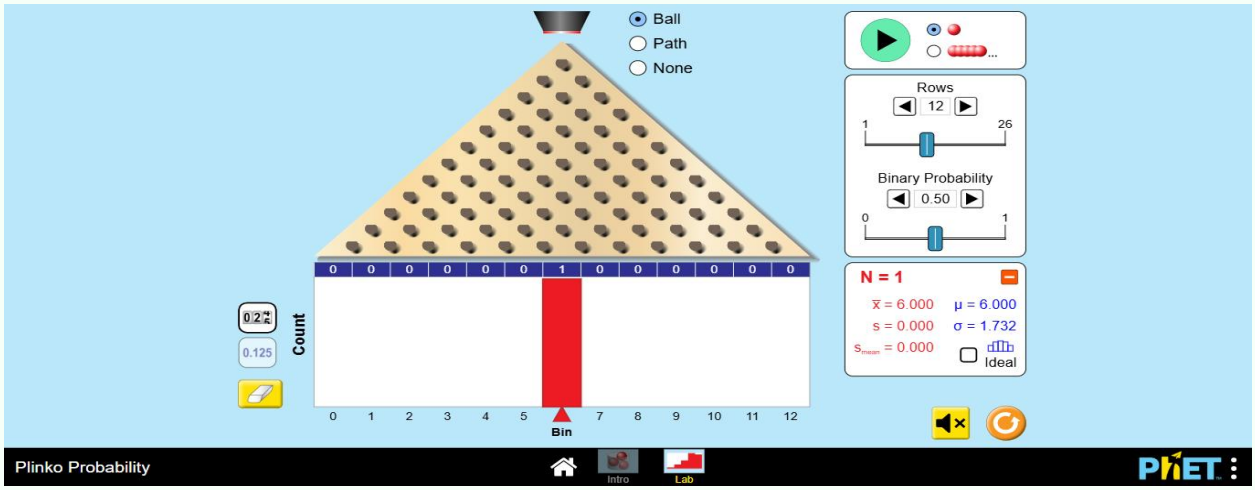
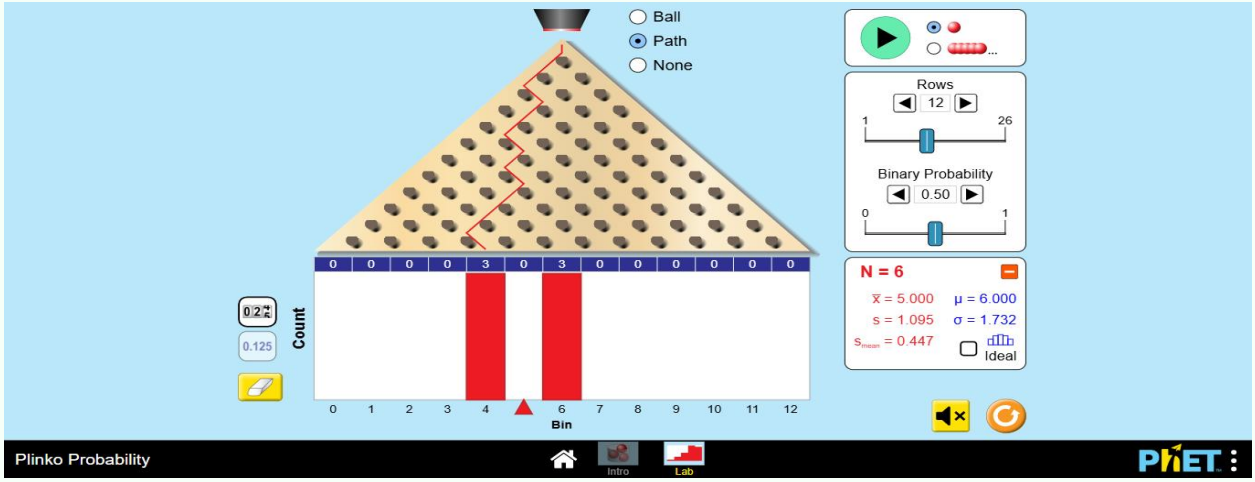


For example, in the pictures above, the test is performed to determine which lane is the most likely to land on for N=100 balls. In the Lab part of the program, there is an opportunity to perform calculations for each situation: For N=1





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Here:
• Green play button: to start the simulation;
• Red dots: Balls or particles that have started to fall;
• "Rows" parameter: Indicates how many rows there are;
• "Binary probability": Indicates the probability that each particle will move left or right (here 0.50, i.e. equally likely);
• Statistical indicators: N=0: (Number of balls)
• X(mean): Average value.
• S(standard deviation): Sample variance
• μ(mathematical expectation): Theoretical mean
• σ(standard deviation): Standard deviation

DISCUSSION

Student Benefits of Simulation
• **Visual and Interactive Explanations**: Students gain a deeper understanding of probability and randomness by seeing it in action.
• **Real-Time Experimentation**: Students can experiment with probability and randomness by seeing the results.
• **Statistical Results**: Simulations help students perform statistical calculations, understand probability distributions, and analyze them.

SUMMARY

Digital technologies can help students engage in more effective and interactive ways when teaching probability theory. Through these methods, students not only learn theoretical knowledge, but also learn how to apply it in practice.
PhET simulations provide students with an interactive and visual way to learn probability theory. This platform is an effective tool for students to reinforce theoretical knowledge and improve their understanding through practical examples. The program has the option to try out the experiment first, which will help you get a full picture of the test.

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