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Learning & Teaching
PK 12

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AUTHOR NAMES:

Lee, Jane HyoJin; and Flavin, Eunhye

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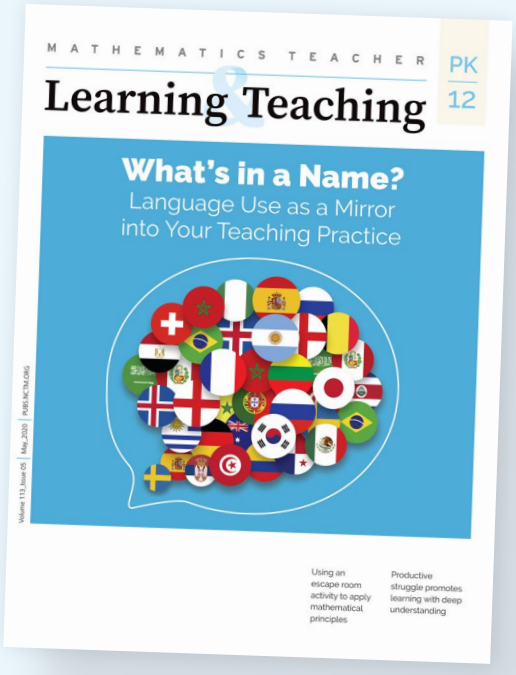
CONTACT: mtlt@nctm.org

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# GPS: AI Decision Making and Statistical Modeling

Growing Problem Solvers provides four original, related, classroom-ready mathematical tasks, one for each grade band. Together, these tasks illustrate the trajectory of learners' growth as problem solvers across their years of school mathematics.

Jane HyoJin Lee and Eunhye Flavin

**Artificial Intelligence (AI) is** crucial in analyzing data to classify, predict, and make decisions across sectors such as education, healthcare, business, and finance. Data-driven platforms like Amazon, YouTube, and Spotify implement effective decision-making processes to provide personalized services to users. AI decision-making algorithms, empowered by probabilistic models, can make effective and sensible judgments (Amir, 2014; Denœux et al., 2020).

June's Growing Problem Solvers focuses on decision-making processes that use probability concepts. Probability is one of the fundamental mathematical concepts used in AI algorithms (De Raedt et al., 2016). Each grade band task invites students to use various probability concepts to understand how widely used video-sharing platforms suggest and recommend content to users. Video-sharing platforms collect data such as demographic information, viewing history, and popularity among similar users and then use this data to recommend content that users might like. This recommendation process requires mathematical modeling. Similar to modeling in other contexts, solutions can vary depending on how key variables are identified, how results are interpreted, and how the sensibility of solutions is reasoned. Our goal is to help students understand key AI algorithms that involve such variability and develop the ability to make informed judgments about AI-generated outputs.

The four tasks focus on Standard for Mathematical Practice 4 – Modeling with mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA Center and CCSSO], 2010). We identify the mathematics content and practice standards aligned with the four mathematical tasks we designed in Table 1. PK–2 students are introduced to the meaning of probability by counting and comparing the numbers. Grades 3–5 make sense of probability terms such as "likely" and "unlikely" and probability concepts using words, fractions, and decimals. Grades 6–8 tasks involve using dice to design experiments, explore possible outcomes, and compute the probability of specific events. Last, 9–12 students collect and analyze survey data, learning to calculate conditional probabilities from the data when multiple factors are involved.

***Table 1*** Common Core State Standards for Mathematics by Grade Band for the Tasks Presented

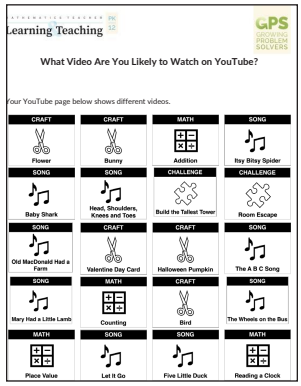
| Grade Band | Common Core State Standards for Mathematics |
|---|---|
| K–2 | 2.MD.10: Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. |
| 3–5 | 5.NBT.2: Understand the place value system. (More specifically, students use the relationship between decimals and fractions.) |
| 6–8 | 7.SP.3: Investigate chance processes and develop, use, and evaluate probability models |
| High School | HSN.S-CP.1: Understand independence and conditional probability and use them to interpret data |

*Note.* NGA Center & CCSSO (2010).

## PK–2

The PK–2 task What Video Are You Likely to Watch on YouTube? (link online), introduces counting and probability in the context of a video-sharing platform. Students will predict which videos might appear on their recommendation page using the counting result. The student worksheet includes 20 videos across four categories: craft, song, mathematics, and challenge. Teachers may adjust the number of video options to align with the CCSSM standard. Kindergarteners may focus on up to two categories, first graders on three, and second graders on all four.

The task begins by having students count the total number of videos and identify the types on a YouTube page in the worksheet. Students then count the number of videos in each type to compare quantities. Teachers can extend this step by having students summarize the data using visual representations such as picture graphs or bar graphs. Employing various mathematical representations helps deepen conceptual understanding. We also recommend teachers explicitly use comparison terms like "more than" and "less than," as students often find these challenging. Teachers may ask, "How many more song videos are on your YouTube page than challenge videos?"




The PK–2 task ends with a discussion question: "Which kind of video do you think you will watch the most tomorrow? Explain why you think so." This discussion guides students to explore the probability of an event occurring based on the categorized data and supports the development of statistical reasoning.

**Jane HyoJin Lee**, jlee7@stonehill.edu, is an associate professor of mathematics at Stonehill College in Easton, MA, where she teaches and conducts research in applied mathematics. Beyond her research, she has a strong interest in K-12 mathematics education, particularly in developing effective and innovative teaching methods for secondary students pursuing STEM fields.

**Eunhye Flavin**, eflavin@gatech.edu, is a senior research scientist (research faculty member) at the Georgia Institute of Technology's Center for Education Integrating Science, Mathematics, and Computing. Her research focuses on pedagogical mediations, including task design and technology development, to support students and teachers in mathematics education.

*Note*. Both authors contributed to this article equally.

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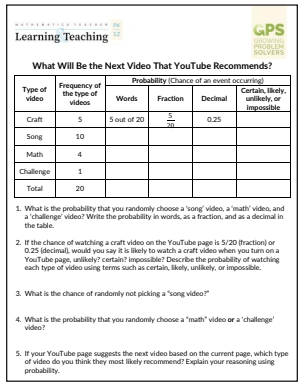
## 3–5

In the 3–5 task What Will Be the Next Video That YouTube Recommends? (link online), we engage students in expressing probability in various forms and using this information to predict what video they are likely to be recommended. Start the task by leveraging everyday language related to probability to enhance student conceptual understanding: certain, likely, unlikely, and impossible. Teachers can use real-world examples to connect terms to numerical representations: "If the forecast reports a 90% chance of rain tomorrow, is it likely or unlikely to rain? Would you bring an umbrella?"

Once students understand these connections, guide them to focus on direct probability. Then, have students practice expressing it in various ways, as shown in the table (Q1-Q2). Once students understand direct probability, we recommend teaching converse probability: "What is the probability that you randomly do **not** choose a 'song video'?" (Q3). As an additional challenge, teach the probability of event A or event B occurring (Q4). Emphasizing that students can choose only one video at a time will enhance their understanding of an independent event.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**What Will Be the Next Video That YouTube Recommends?**

| Type of video | Frequency of the type of videos | Probability (Chance of an event occurring) | | | |
|---|---|---|---|---|---|
| | | Words | Fraction | Decimal | Certain, likely, unlikely, or impossible |
| Craft | 5 | 5 out of 20 | $\frac{5}{20}$ | 0.25 | |
| Song | 10 | | | | |
| Math | 4 | | | | |
| Challenge | 1 | | | | |
| Total | 20 | | | | |

1. What is the probability that you randomly choose a 'song' video, a 'math' video, and a 'challenge' video? Write the probability in words, as a fraction, and as a decimal in the table.
2. If the chance of watching a craft video on the YouTube page is 5/20 (fraction) or 0.25 (decimal), would you say it is likely to watch a craft video when you turn on a YouTube page, unlikely? certain? impossible? Describe the probability of watching each type of video using terms such as certain, likely, unlikely, or impossible.
3. What is the chance of randomly not picking a "song video?"
4. What is the probability that you randomly choose a "math" video **or** a 'challenge' video?
5. If your YouTube page suggests the next video based on the current page, which type of video do you think they most likely recommend? Explain your reasoning using probability.

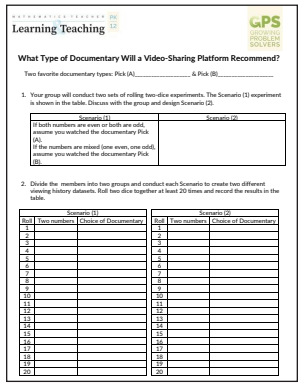
The task concludes with a discussion question: "Which type of video do you think the YouTube page most likely recommends?" Students may respond, "YouTube will recommend a song video because half of the videos this user watched are songs." To lead a discussion about controlling the recommendation algorithm, teachers can ask, "If you don't like watching song videos anymore, how would you change the YouTube algorithm?"

## 6–8

The 6–8 task What Type of Documentary Will a Video-Sharing Platform Recommend? (link online), considers a user's viewing history data to make recommendations. Each group selects two favorite documentary types from the following options: Biography, History, Music & Concert, Science & Nature, Social & Cultural, Sports, and Travel & Adventure. Students perform two dice-rolling experiments to create distinct viewing history datasets using two scenarios. After reading Scenario (1), have students construct Scenario (2) to deepen their understanding of how dice outcomes yield different results (Q1-Q2). Teachers may suggest examples:

- If the two numbers are the same, assume you watched the documentary Pick (A); otherwise, Pick (B).
- If the sum of the two numbers is less than 10, assume you watched the documentary Pick (A); otherwise, Pick (B).

The worksheet (Q3-Q8) focuses on empirical probability. Students calculate probabilities and expected frequencies using their datasets, connecting this understanding to how video-sharing platforms may use probability for recommendations.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**What Type of Documentary Will a Video-Sharing Platform Recommend?**

Two favorite documentary types: Pick (A)_____ & Pick (B)_____

1. Your group will conduct two sets of rolling two-dice experiments. The Scenario (1) experiment is shown in the table. Discuss with the group and design Scenario (2).

| Scenario (1) | Scenario (2) |
|---|---|
| If both numbers are even or both are odd, assume you watched the documentary Pick (A).<br>If the numbers are mixed (one even, one odd), assume you watched the documentary Pick (B). | |

2. Divide the members into two groups and conduct each Scenario to create two different viewing history datasets. Roll two dice together at least 20 times and record the results in the table.

| Scenario (1) | | | Scenario (2) | | |
|---|---|---|---|---|---|
| Roll | Two numbers | Choice of Documentary | Roll | Two numbers | Choice of Documentary |
| 1 | | | 1 | | |
| 2 | | | 2 | | |
| 3 | | | 3 | | |
| 4 | | | 4 | | |
| 5 | | | 5 | | |
| 6 | | | 6 | | |
| 7 | | | 7 | | |
| 8 | | | 8 | | |
| 9 | | | 9 | | |
| 10 | | | 10 | | |
| 11 | | | 11 | | |
| 12 | | | 12 | | |
| 13 | | | 13 | | |
| 14 | | | 14 | | |
| 15 | | | 15 | | |
| 16 | | | 16 | | |
| 17 | | | 17 | | |
| 18 | | | 18 | | |
| 19 | | | 19 | | |
| 20 | | | 20 | | |

We also recommend exploring whether the experimental results align with theoretical expectations using the following questions:

- How many different outcomes are possible from rolling two dice?
- What are the theoretical probabilities of choosing Pick (A) in each of the two scenarios?
- Are your experiment results close to the theoretical probabilities?

These questions enhance students' understanding of probability concepts. Demonstrating a simple coin toss example reinforces how increasing sample size brings empirical results closer to theoretical probabilities.

Finally, we suggest ending with a discussion on the limitations of simple probability-based recommendations. Sharing student experiences with video-sharing platforms can enrich discussions.

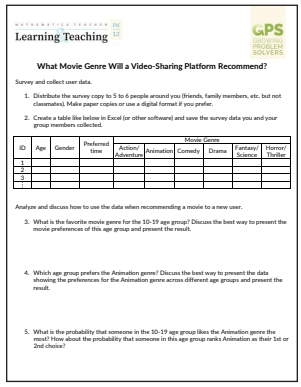
## 9–12

The 9–12 task What Movie Genre Will a Video-Sharing Platform Recommend? (link online), uses demographic data to make recommendations. Students start with data collection (Q1-Q2) via a paper-based or electronic survey (e.g., Qualtrics). The survey includes four questions:

a) What is your age group?
b) How do you identify your gender?
c) When do you prefer to watch a movie?
d) Which movie genres do you like? (Please rank them from 1 to 6, with 1 being your most favorite and 6 being your least favorite.)

To simplify data aggregation, guide students to limit survey options: 5–6 groups for (a), 2–3 choices for (b) and (c), and 5–6 genres for (d). Groups of 3–4 students then consolidate their data into a table using Excel or similar software. Teachers should adjust worksheet phrasing to reflect the survey options chosen by the students.

The task (Q3-Q9) guides students in analyzing the relationship between preferred movie genres and demographic information while discussing how the results are used to suggest a movie genre to a new user. Encourage students to use various data visualization techniques, such as tables, bar graphs, and pie charts, to present their analysis. Teaching conditional probability (Q5-Q7) helps students analyze data across multiple factors. Lastly, guide students to explore ways to refine the suggestion algorithm (Q10-Q11). For example, students may suggest using existing data (e.g., combining class data) or gathering additional data (e.g., race, location, weather).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GPS GROWING PROBLEM SOLVERS

**What Movie Genre Will a Video-Sharing Platform Recommend?**

Survey and collect user data.

1. Distribute the survey copy to 5 to 6 people around you (friends, family members, etc. but not classmates). Make paper copies or use a digital format if you prefer.
2. Create a table like below in Excel (or other software) and save the survey data you and your group members collected.

| ID | Age | Gender | Preferred time | Movie Genre | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Action/ Adventure | Animation | Comedy | Drama | Fantasy/ Science | Horror/ Thriller |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |

Analyze and discuss how to use the data when recommending a movie to a new user.

3. What is the favorite movie genre for the 10-19 age group? Discuss the best way to present the movie preferences of this age group and present the result.
4. Which age group prefers the Animation genre? Discuss the best way to present the data showing the preferences for the Animation genre across different age groups and present the result.
5. What is the probability that someone in the 10-19 age group likes the Animation genre the most? How about the probability that someone in this age group ranks Animation as their 1st or 2nd choice?

We recommend concluding by discussing how algorithm-based platforms like Netflix or Amazon influence user choices. Exploring the benefits and drawbacks of using demographic data can enrich the conversation.

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