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# Using Baye's Theorem of Conditional Probability to Analyze Course Performance

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# Baye's Theorem

1. Used to update prior beliefs about the probability of an event, *given new evidence*

2. Derived from the concept of conditional probability

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# Applications of Baye's Theorem

1. Medical Testing/Diagnosis
2. Operations Management/Quality Control
3. Spam Filtering

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# Baye's Theorem

Prob of $Event_1$ given $Event_2$ is true

Prob of $Event_1$ = Prior Probability

$$Prob(Event_1 \mid Event_2) =$$

Prob of $Event_2$ given $Event_1$ is true

$$\frac{Prob(Event_1) \times Prob(Event_2 \mid Event_1)}{Prob(Event_2)}$$

Result = Posterior Probability

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# Medical Test Example

**Prob(Disease | Test +) =**

Prior Probability of Disease

Prob of + Test given disease is present

**.05 x .95**

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**.15** → Overall Prob of + Test

Posterior Probability = 31.7%

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# Analyzing Sequential Courses

1. Examine pre-requisite / next-level course pairs
   - ENGL 1310 (Writing I) / ENGL 1320 (Writing II)
   - MATH 1710 (Calculus I) / MATH 1720 (Calculus II)

2. Calculate prior probabilities for 2nd course grades
   - Probability of A, B or Higher, Etc.

3. Use 1st course grades & Baye's theorem to update prior probabilities

4. Compare posterior & prior probabilities

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# Population / Data Set

*For each course pair…*

1. Select students passing first course, Fall 2013 – Fall 2017

2. Of the above group, limit to students taking 2nd course within the next year

3. Of the above group, pare down to those completing 2nd course

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# Calculus I / Calculus II Example

1. Total Population = 1,628 students

2. Overall Probability of B or Higher in Calculus II = 52.3% (Prior Probability)

3. Probability (B / Higher) in Calculus II, given B in Calculus I = ???? (Posterior Probability)

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# Calculus I / Calculus II Example

$$\text{Prob}(B+_{\text{Cal II}} \mid B_{\text{Cal I}}) =$$

= Prob of B in Calculus I **&** B+ in Calculus II

$$\frac{\text{Prob}(B+_{\text{Cal II}}) \times \text{Prob}(B_{\text{Cal I}} \mid B+_{\text{Cal II}})}{\text{Prob}(B_{\text{Cal I}})}$$

= Prob of $B_{\text{Cal I}}$ & $B+_{\text{Cal II}}$ **+** Prob of $B_{\text{Cal I}}$ & $<B_{\text{Cal II}}$

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# Calculus I / Calculus II Example

$$\text{Prob}(B+_{\text{Cal II}} \mid B_{\text{Cal I}}) = \frac{(205 / 1628)}{([205/1628] + [258/1628])}$$

# students with B in Calculus I **&** B+ in Calculus II

Total # students

# students with B in Calculus I **&** <B in Calculus II

Posterior Probability = 44.3%

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# Calculus I / Calculus II: Prior vs. Updated Probabilities

| Grade | Prior Probability: Cal II Grade = Grade or Higher | Posterior Probability: Given Cal I Grade = Grade |
|---|---|---|
| A | 31.2% | 63.0% |
| B | 52.3% | 44.3% |
| C | 69.4% | 42.9% |
| D | 80.5% | 49.0% |

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# Writing I / Writing II: Prior vs. Updated Probabilities

| Grade | Prior Probability: Wri II Grade = Grade or Higher | Posterior Probability: Given Wri I Grade = Grade |
|---|---|---|
| A | 50.7% | 66.8% |
| B | 80.2% | 74.6% |
| C | 90.9% | 74.6% |
| D | 93.4% | 70.9% |

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# Potential Issues

1. Skills/Concepts Not Aligned Between 1st & 2nd Course
2. Grade Inflation in 1st / Pre-Requisite Course
3. ~~Excessively Stringent Grading in 2nd Course~~
4. ~~Large-Scale Decline in Student Effort~~

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# 2nd Course Performance & Next-Term Persistence

| 2nd Course | 2nd Course Grade vs. 1st Course Grade | Persistence Rate |
|---|---|---|
| Calculus II | Equal to / Greater Than | 95.1% |
| | Lower Than | 86.5% |
| Writing II | Equal to / Greater Than | 89.0% |
| | Lower Than | 77.6% |

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# Calculus I / Calculus II: Updated Probabilities by Instructor Rank *(Calculus I Grade = B)*

| Rank | Prior Probability: Cal II Grade = B or Higher | Posterior Probability: Given Cal I Grade = B & Rank = Rank |
|---|---|---|
| Prof/Instructor | 52.3% | 68.0% |
| Adjunct/Other | 52.3% | 38.0% |
| Teaching Assistant | 52.3% | 48.4% |

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# Calculus I / Calculus II: Updated Probabilities by Instructor Rank
*(Calculus I Grade = C)*

| Rank | Prior Probability: Cal II Grade = C or Higher | Posterior Probability: Given Cal I Grade = C & Rank = Rank |
|---|---|---|
| Prof/Instructor | 69.4% | 65.9% |
| Adjunct/Other | 69.4% | 35.9% |
| Teaching Assistant | 69.4% | 53.2% |

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# Writing I / Writing II: Updated Probabilities by Instructor Rank *(Writing I Grade = B)*

| Rank | Prior Probability: Wri II Grade = B or Higher | Posterior Probability: Given Wri I Grade = B & Rank = Rank |
|---|---|---|
| Adjunct/Other | 80.2% | 74.9% |
| Teaching Assistant | 80.2% | 74.5% |

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# Writing I / Writing II: Updated Probabilities by Instructor Rank *(Writing I Grade = C)*

| Rank | Prior Probability: Wri II Grade = C or Higher | Posterior Probability: Given Wri I Grade = C & Rank = Rank |
|---|---|---|
| Adjunct/Other | 90.9% | 75.6% |
| Teaching Assistant | 90.9% | 73.8% |

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# Thank You

*Session Evaluation Form Available via the Conference App*

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