Multiplicative Grading

Motivating Question

- How to design a grading system that **accurately evaluates student mastery** while also **valuing their engagement and effort**, especially in the era of AI tools like ChatGPT?

Grade Calculation Properties

- Sensitive to a student's own skill/knowledge
  - Typically measured with exams or open-ended projects
- Requires continued engagement/dedication
  - This can be tracked using homework, class participation, engagement with group activities, etc.
- Utilizes the full range of allowable grades
- Incentivizes student learning (and not point chasing)
  - The path of least resistance to a good grade should involve learning the material, not outsourcing to AI
- Fair, understandable, consistent, not intimidating, etc.

Standard Grade Calculations

- Homework and exams/projects weighted roughly equally, with some additional participation points
- Sensitive to a student's own skill/knowledge?
  - No: it's easy to fail an exam and still get a high grade
- Requires continued engagement/dedication
  - Yes: homework/participation is needed for a high grade
- Utilizes the full range of allowable grades
  - No: there is a high grade floor with minimal effort/learning
- Incentivizes student learning (and not point chasing)
  - No: AI can solve homework problems

Exam-Heavy Grade Calculations

- Exams/projects account for all/most of the final grade
- Sensitive to a student's own skill/knowledge?
  - Yes: the grade cannot be easily manipulated by AI
- Requires continued engagement/dedication
  - No: a student could skip all classes/homework
- Utilizes the full range of allowable grades
  - Yes (as long as the exam/project does)
- Incentivizes student learning (and not point chasing)
  - No: students with some background might coast

A New Grading Paradigm

- Insight: to require both skill/knowledge (measured via exams/projects) and continued effort (measured via homework/participation), instead of taking a weighted sum of these components, multiply them together
  - We'll refer to this as multiplicative grading

Multiplicative Grade Calculation

- Three components:
  - Component **A** represents active engagement
    - Weighted combination of homework, class participation, project milestones, etc.
    - Students are expected to get around 100% on this and can earn extra credit here
      - To not incentivize AI use, I grade homework on completion
  - Component **B** represents skill/knowledge
    - Weighted combination of exams and open-ended projects
  - (Optional) Component **C** is a course evaluation multiplier
- The final grade is the product **A * B * C**

Multiplicative Grade Calculations

- Multiply skill grade with engagement grade
- Sensitive to a student's own skill/knowledge?
  - Yes: a good exam/project score is required for a good grade
- Requires continued engagement/dedication
  - Yes: homework/participation is also needed to score well
- Utilizes the full range of allowable grades
  - Yes: a student using AI for homework who fails the exam will fail the class
- Incentivizes student learning (and not point chasing)
  - Yes: using AI on homework might harm exam grades

Hypothesis (Pre-Implementation)

- High-performing and engaged students should perform at least as well as they would in a standard grading system
- Skipping homework or not participating in class has a substantial impact on the final grade
- Completing homework but not understanding the material does not lead to a good grade
- There should be a wider distribution of grades compared to a standard grading system

Results (2024-25 School Year)

- Unattempted homework assignments dropped from 5.5% to 0.2% (a different class this year was 0.8%)
- The median grade changed by less than one percentage point between semesters
- Exam and project grades went up slightly
- The grade distribution had a similar shape to a traditional grade calculation but was more spread out
- Students spent a similar amount of time on homework in both semesters

Conclusions

- Grades seemed to better reflect the student's level of mastery, while also rewarding effort
  - High-performing students still get good grades but students who have not mastered the material do not get artificially high grades
- Homework completion rates went up to nearly 100%
- Students generally had mixed impressions*
- Anecdotally, despite similar median grades, I felt that the grades were inflated using a standard system, whereas they were earned with multiplicative grading