Investigating Student Confidence to Optimize Student Performance

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Abstract

In this project we analyzed data from CourseKata, an online statistics and data science learning platform, to compare student confidence levels with student performance. Our analysis suggests that students who have increasing grades tend to exhibit lower confidence levels, while those with decreasing grades tend to overestimate their abilities. Moreover, those who exhibit higher engagement with the course material tend to score higher at the end of the course compared to less engaged peers.

Introduction

A key inspiration for our project was the Dunning-Kruger effect [2], a trend where more novice students tend to be overconfident in what they think they know, and more expert students tend to be less confident. We wanted to specifically compare progressive student confidence levels with both their engagement with the material as well as with their subsequent end of chapter scores. We organized the data by chapter and sorted out subsets of students with varying confidence levels, engagement, and end-of-chapter scores.

It is essential to note that earlier chapters in the course require a shallower understanding of the material. Simple recall of information rather than a deeper conceptual understanding was all that was necessary. Thus, chapters in the beginning of the book fall into a lower tier of Bloom's taxonomy, while later chapters fall into a higher tier [1]. Observing changes in scores across chapters not only reflects changes over time, but also within different tiers of conceptualization.

Data Description

The data for the following analysis was collected by CourseKata in 2023. A sample size of 1625 students from 11 U.S educational institutions enrolled in 48 college-level introductory statistics and data science courses was used. In the 48 courses, three different textbooks were used as teaching material: Advanced Statistics and Data Science (college level), Statistics and Data Science (college level), and Advanced Statistics and Data Science I (high-school level). The data provided by CourseKata

included students' interactive data with the online platforms' assessments of confidence levels, chapter scores, engagement time on the platform, specifically the page view data.

Discoveries

Figure 1: Average student confidence per chapter separated by increasing or decreasing grades. Chapter confidence scores were collected at the beginning of the following chapter. Students were asked to reflect on how confident they are in the material covered in the previous chapter, and this confidence level was ranked discretely from 1-6. Here, students who increased their grades throughout the course seem to be less confident in the material until the end of the course, where their confidence sharply increases.

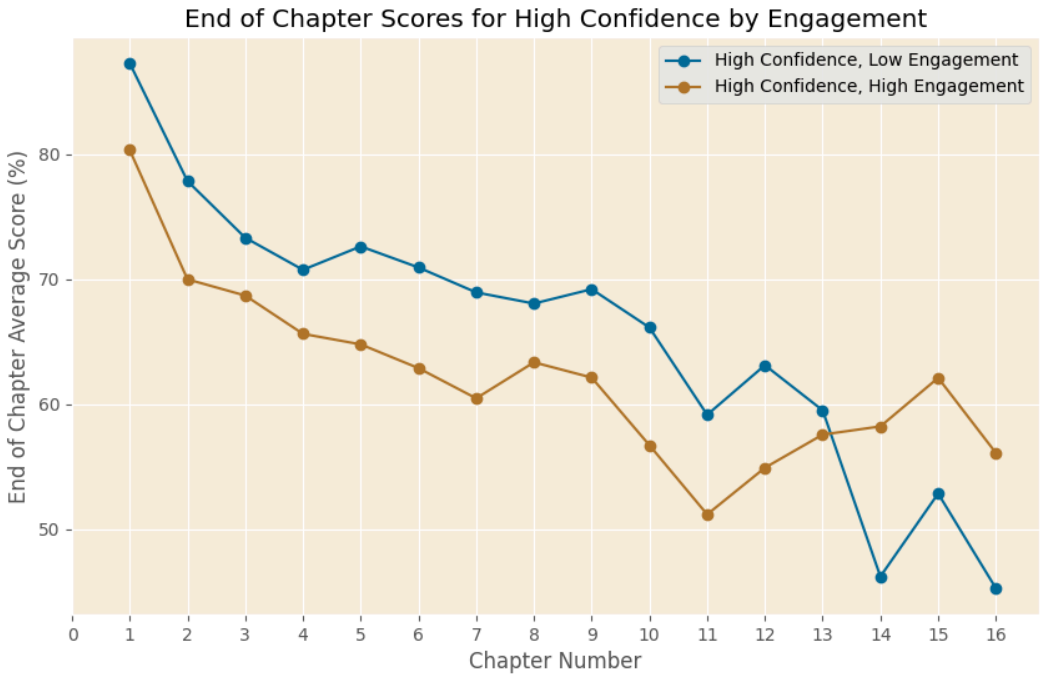

Figure 2: Average scores in highly confident students separated by engagement. Students who responded "Strongly agree" to the statement "I am confident in what I learned in the previous chapter," following chapter 1 are included in the graph. Here, we see that highly engaged students are generally scoring lower than students who have low engagement until the final chapters, where the low engagement students have a sharp decline in score, and high engagement students increase their score.

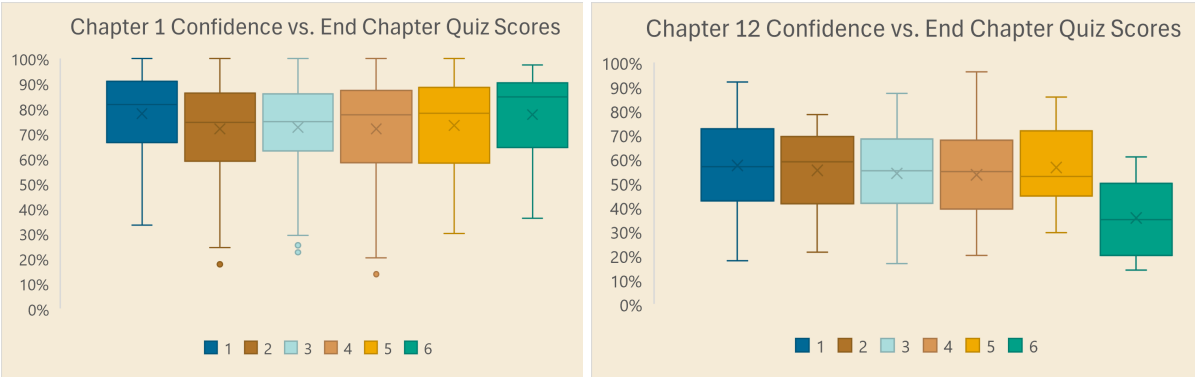

Figure 3: Student confidence and end of chapter scores. Groups are separated by confidence levels rated 1-6. These confidence levels pertain to the same chapters to which the scores are given. Highly confident students tend to score lower than less confident students in later chapters.

Methods

Matplotlib was utilized to generate line graphs, while box and whisker plots were generated using Excel.

Confidence Level Over Chapter Span

Using Pandas dataframes, students were selected based on their end of chapter (EOC) scores, specifically identifying those with increasing and decreasing grades. Due to limited data availability, the analysis concentrated on chapters one through twelve. Average confidence values were tracked for each chapter, categorizing students into three subsets: increasing grades, decreasing grades, and the entire cohort (Figure 1).

EOC Scores for High Confidence for Engagement

Engagement was measured by the time students spent interacting with the coursebook (clicking or scrolling). After two minutes of idleness, the engagement timer was stopped. Engagement was separated by quantiles: students who engaged with the material above the third quartile were labeled “High Engagement,” while students who engaged with the material below the first quartile were labeled “Low Engagement.” Students with high confidence scores were subsetted based on their engagement within the CourseKata system. Their average end of chapter score was tracked as the chapters progressed (Figure 2).

Box and Whisker Plots

Box and Whisker Plots were generated to discover the link between student confidence level and their performance on a chapter review quiz. The Student Identifier was used to match up student’s EOC Quiz scores to their confidence levels with the material. The data was combined and organized using Excel’s Pivot tables feature. The data points from the 12 chapters each were organized into 6 groups based on their confidence level ranging from 1 to 6. Each chapter’s scores were placed in a box and whisker plot to highlight Q1, Q2, Q3, the mean, the minimum, the maximum and any outliers.

Results and Discussion

The overall student population and those experiencing decreasing grades exhibited similar levels of confidence at the end of each chapter (Figure 1). In contrast, students with increasing grades initially displayed high confidence levels. However, they underwent a rapid decline in confidence before experiencing a significant recovery, reaching a level of confidence comparable to or even surpassing their counterparts. This phenomenon demonstrates the Dunning-Kruger Effect, wherein individuals initially overestimate their abilities, leading to a realization of their limitations, followed by a gradual increase in confidence as they acquire competence [2]. This correlation underscores the interplay between overconfidence, the Dunning-Kruger Effect, and academic performance.

To tackle this challenge, educators should emphasize the importance of continuous engagement throughout the course. They encourage students to be flexible in their learning strategies as the course becomes more difficult. By nurturing a culture of sustained engagement and adaptable learning, teachers can enable students to rebuild their confidence after setbacks.

Additionally, students with high confidence scores and low engagement outperformed those with high confidence and high engagement (Figure 1). This observation suggests that students with lower engagement may possess a deeper familiarity with the material, reducing their perceived need for additional study. Despite a general trend of declining scores as the course progresses, an interesting shift occurs at chapter 11: students with higher engagement levels start to improve, while those with lower engagement continue to decline. By chapter 13, students with higher engagement surpass their low-engagement counterparts, indicating that the material becomes more challenging at this point and mere familiarity with the content does not guarantee success.

Finally, toward the end of the course, there was a significant divergence between student confidence levels and their average end-of-chapter scores. Initially, in the first chapter, both confidence levels and scores were quite similar. However, by the twelfth chapter, a paradox emerged where students with higher confidence tended to achieve lower scores. This observation suggests the presence of overconfidence among students. To

address overconfidence, students should critically investigate their understanding and seek feedback regularly.

Notably, the topics covered during this period in the CourseKata textbook focus on evaluating models. Evaluating and interpreting models requires a deeper level of understanding and processing rather than simple recall as previous chapters seemed to focus on. Students exhibiting the Dunning-Kruger effect tend to be more familiar with simple recall, or the knowledge tier of Bloom's taxonomy, than analysis of information, which is found in higher tiers [1][2]. It appears that students with high engagement begin to excel in the later chapters, whereas others with low engagement experience a decline in performance. This underscores the notion that confidence in the material alone does not ensure academic success.

To support students facing a decline in grades during this period, teachers should consider implementing additional mandatory assignments to encourage student engagement and reinforce learning. Group assignments may also be beneficial. Pairing highly engaged students with those who have lower engagement may supplement the development of the students who are seeing a decline in their scores.

References

[1] Adams, N. E. (2015). Bloom's taxonomy of cognitive learning objectives. *Journal of the Medical Library Association : JMLA*, *103*(3), 152–153. https://doi.org/10.3163/1536-5050.103.3.010

[2] Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, 77(6), 1121.