

Exploratory PCA and AI for Assessment Analysis

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Assessment plays a critical role in improving student learning outcomes (Brown, 2022; Karaman, 2021). Exploratory Principal Component Analysis (PCA) can identify latent skill structures in exams, offering educators insight into how well assessments align with their goals (Jolliffe, 2002). Simultaneously, emerging AI tools like ChatGPT-4 Turbo present opportunities for enhancing data analysis accessibility in educational research. However, as AI can hallucinate facts, it requires careful validation (Lee, 2023). Using the author's College Algebra Exam 1 as a test case, this study sought to 1) investigate the latent skill dimensions in a College Algebra exam using PCA, and 2) Evaluate ChatGPT-4 Turbo's reliability and utility in conducting PCA.

Pre-existing data were collected from a 19-question College Algebra exam administered to 60 students across two sections of 30 students each, both taught by the author. ChatGPT-4 Turbo was tasked with performing a PCA, and the author conducted a PCA in R and compared results. Interpretation of the PCA results in both ChatGPT-4 Turbo and R focused on identifying the underlying skills being tested by each component. Key ChatGPT prompts and outputs were saved and are included in the poster (via QR code) for reproducibility.

The outputs from R and ChatGPT differed slightly, though the results were similar enough that the interpretation of the underlying skills was not different. Inspection of the chat history shows that ChatGPT wrote its own code to execute the PCA, and it seems its algorithm differs from R's, given the mildly different numerical outputs. This outcome highlights the potential of ChatGPT but underscores the need for human oversight (Lee, 2023). Preliminary findings identified components reflecting distinct skill areas, such as graphical reasoning and multi-step algebraic problem-solving. The component that explained the most variance suggested a counterindication between procedural and conceptual fluency. As literature overwhelmingly suggests that conceptual fluency naturally increases procedural fluency, this result warrants further exploration (Hurrell, 2021; Rittle-Johnson, Schneider, & Star, 2015). Tools such as PCAs and factor analysis offer a potential framework for uncovering skill structures in exams, which can help educators refine and align test design with learning goals (Jolliffe, 2002). While ChatGPT offers accessible entry points for conducting data analysis, human validation remains critical to ensure reliability (Lee, 2023). The intent of this poster is to highlight the potential of this methodology, rather than focusing exclusively on the structure of a single professor's non-standardized college algebra exam.

Since this study, a new AI version, ChatGPT-4o, was released. In the future, the author will investigate this new version's capabilities in this context. If sufficiently reliable, the methodology could be extended to other datasets to enhance generalizability. Further, AI is a developing field, and best practices are still being determined, such as making prompts transparent for reproducibility. Finally, the counterindication between procedural and conceptual fluency in the author's College Algebra class merits further investigation, as these are typically expected to be positively correlated (Rittle-Johnson, Schneider, & Star, 2015). This study demonstrates the utility of PCA in assessing alignment and explores the potential of AI tools in conducting analyses. While AI offers promising avenues of analysis in educational research, human oversight remains crucial to ensure accuracy and validity.

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