What is VHDL and why is it Difficult?
• VHDL is a hardware description language that can model the behavior of digital systems.
  - It is concurrent: statements generally occur simultaneously, as opposed to sequentially.
  - Requires a basic understanding of hardware being designed.
  - Typically, novice VHDL programmers first learned a sequential programming language.
  - Results in a variety of methods, some erroneous, for completing problems.

What Data We Have

Drawing Solution Trajectories
• Goal of connecting a student’s submissions based on their different approaches to solving a problem.
• Use text-based comparison of code.
• Find first passing submission and compare all previous submissions to it to indicate progress.
• Submissions equally like the final submission have the same rank, and submissions that are identical share the same node.
• Edge between current submission and most similar previous submission.

Also, have date and time when code was submitted.

Solution Trajectory Metrics
• Use Dijkstra’s algorithm to determine the shortest path from initial submission to final submission, which suggests the percentage of submissions that contributed to the student’s final solution.
• Timestamps can reveal trends about when students typically submit their assignments.

Grouping Students by Code:
• Goal of grouping students based on similarities in coding process and solution.
• Affinity matrix calculated with two methods: using Wasserstein metric from optimal transport between different students’ code submissions and computing similarity between students’ solutions to a problem.
• Spectral Embedding performed on affinity matrix and then k-means clustering used.
• Alternate approach: counting occurrences of keywords in solutions and use these totals as features in k-means clustering.

Sample Student Solution Trajectories along with Diffviewer Tool

Percentages for a Selection of Problems
Timeline of when Students Submitted Their Code Relative to the Deadline

Optimal-Transport Method
Similarity Method
Bag-of-Keywords Method