Balancing Act: A Theory on the Interactions Between High-Level Task-thinking and Low-Level Implementation-thinking of Novice Programmers

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We gave students problems with varying degrees of novelty

1. compose known tasks/subproblems in new ways

2. solve and compose new tasks/subproblems

Question: How would they approach such problems,
given the plans/schemas they've been taught,
alongside the programming tools and techniques they're learning?

Rainfall

Given a list of numbers, produce the average of the non-negative numbers that occur before -999.

Example: rainfall([1, 1, -3, 4, -999, 20]) is 2

Tasks:
Count
Sum
Average 
Ignore Negatives
Terminate 

 new task

 new composition

Max Temps

Given a list of numbers, return max values in each sublist as separated by a delimiter (e.g., 0).

Example: maxTemps([3, 5, 0, 2, 0, 7, 5, 3]) is [5, 2, 7]

Tasks:
Find sublist(s) 
List max
Build results

Methods

Talk-aloud study with CS1 students from two universities

- both universities use the same text and curriculum
- universities differ in emphasis on certain concepts (e.g., in grading)

We audio-recorded and transcribed the sessions, then coded for how students went about each problem. Codes capture which tasks they planned out before coding, how individual tasks were implemented, and when they talked in terms of each of plans and code (among others)

Key Observations

- Students who (mostly) succeeded on either problem talked about problem-level tasks and their compositions before coding
  - Some return to task-level thinking when composing code later

- Students who got stuck but had some initial planning didn't return to thinking in terms of plans after getting stuck

- Students without plans prior to coding don't begin to think about the higher-level plans later; nearly all get stuck

How can we nudge students towards going back to the plan level when they get stuck?
Leveraging examples? Writing contracts?