Strategies that Students Use to Trace Code: An Analysis Based in Grounded Theory

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Results: First Year Students...

- Employ a range of strategies (usually more than one on a given question)
- Use 19 distinct strategies
- Use different strategies on different types of questions
- Often apply strategies poorly
Lister ’04
ITiCSE Working Group

- Followup to McCracken ’01
- Investigated First Year student reading and tracing of code
  - 12 MCQs featuring arrays and loops
  - “Doodles” collected
  - N=556 for all 12 questions, N=37 for think aloud transcripts
- [Lister et. al., SIGCSE Dec 2004], [McCartney et. al. Informatics in Education]
Methodology

- Grounded Theory-based analysis
  - Group reading for “approaches students used to reach an answer” [CAVEAT]
  - Goal: Allow theory to emerge organically from data [Glaser and Strauss]
- Q2 and Q8 selected for representative nature
  - Correctness: Q2 65%, Q8 51% (60% mean)
The good stuff: What students are thinking

Previewing (S1-S4)

- "This time I'm going to look to see what the question wants first. So trying to find the value of count." [Q2, A037]
- "x1 is an array with four integers, x2 is an array with four integers." [Q2, S001]
- "There are 2 variables i1 and i2 that start at 3." [Q2, L019]
- "Uh, Oh, so I just noticed that it’s a nested loop." [Q8, P002]
Understanding New Concepts

“I'm reading over the question. Finding out what an inversion means or is. So I see that it's when a number occurs first in the array is larger than the number that occurs second. And it just gives an example so you understand.” [Q8, A037]
Pattern Recognition

“And the second problem I did is, it's like what I did before, but I just look at these two, so I can just guess, like what it's saying is like when the numbers are different?” [Q2, O003]

“First of all I knew that in the for loop you’re going to compare j to length-1, because the way the arrays are 0 through the number of elements minus 1.” [Q8, O001]

“So once again this is just a fancy method of sorting I would think” [Q8, Q002]
Walkthroughs

Strategizing

- “int x1 is equal to 1, 2, 4, 7 and int x2 is equals to 1, 2 while i1 > 0
  i1, i1 is x1.length which is x1.length = 4
  i1 so i1 = x1.length-1
  x.length is 4-1
  is 4 - 1
  just 3 and i2, x2.length which is 4-1 which is 3
  i2 = 4-1 which is 3
  so both of these are true so I enter the loop” [Q2, P001]

- “And it’s just sort of ... what an inversion is and what this code is trying to do now just sort of thinking what I would logically put in there before I look at any of the answers” [Q8, N001]
Grouping, Differentiation, Elimination

“Yes, so that one has the same problem as the first one ... C has the same problem as A and I can tell it's pretty much comparing ... there are only two differences really. A and C have the same problems and B and D have the same problems.” [Q8, N002]

“So the problem is, is it x.length or x.length-1?” [Q8, P001]

“So it can't be A. So now I'm trying. But I'm not going to bother with B because it's starting out at the beginning of the array for j too. So now I'm looking at C. ... so it would skip the last value in the array so D would not work so the answer is C.” [Q8, A037]
The Remainder

- Thoroughness, Starting Over, Coming Back to the Question Later
- Posing Questions
  - “Ten, why are there ten?” [Q8, T001]
  - “Can this be an endless loop?” [Q2, T003]
- Doodling [Lister, McCartney]
Everyone’s Favorite:

- “I was totally lost on this one, I just took a wild guess.”  [Q8, H002]

- “There was like 5 minutes left and I just picked what I thought looked best at that time.”  [Q8, H003]

- “It would be a complete guess to be honest.”  [Q2, L002]
What to do with this data?

- Develop theories, instruments to test those theories, test, interventions
- Evident theories:
  - See Results
  - Computing versus Test Taking Strategies
Conformance to Existing Theories

- Bloom’s Taxonomy
  - Knowledge: S7
  - Comprehension: S2, S3, S4
  - Application: S9
  - Analysis: S5
  - Synthesis: S10
  - Evaluation: S8

- Deep, Surface, Strategic Learning
Emergent Theories and Success and Failure

- Temporal Groupings
  - Familiarization, Recognition, Modeling, Selecting an Answer
- Syntax, Semantics, Pragmatics
- Success:
  - Not related to strategy applied, but to SUCCESS in applying a strategy
From Here...

- Informed additional studies of what “level” of learning is engendered by these particular questions.
- Encourage future work in exploration of how and when students “go wrong” in employing strategies
  - Can students recognize when this occurs
- Strategy teaching in the classroom