



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

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## Results: First Year Students...

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- 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

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- 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

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- 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

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- 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

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- *"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

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- *"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  $\text{length}-1$ , 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

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- *"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

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- 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:



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- *"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?

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



# Conformance to Existing Theories

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- 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

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- 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...

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- 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