

Patterns in Elementary-Age Student Responses to Personalized & Generic Code Comprehension Questions

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*Computing for ANYONE:
Designing for equity and inclusion*

Have you ever encountered someone who has code that works correctly, but doesn't know why?

Artifacts are integral to CS/CT instruction.



Common Assessment Techniques: Pros & Cons

Artifact analysis:

- + Student code integration (e.g. Scrape, Hairball, Dr Scratch)
- + Fast
- Students use code they do not understand (Brennan et al., 2012)
- Students may understand a concept, but choose not to include it

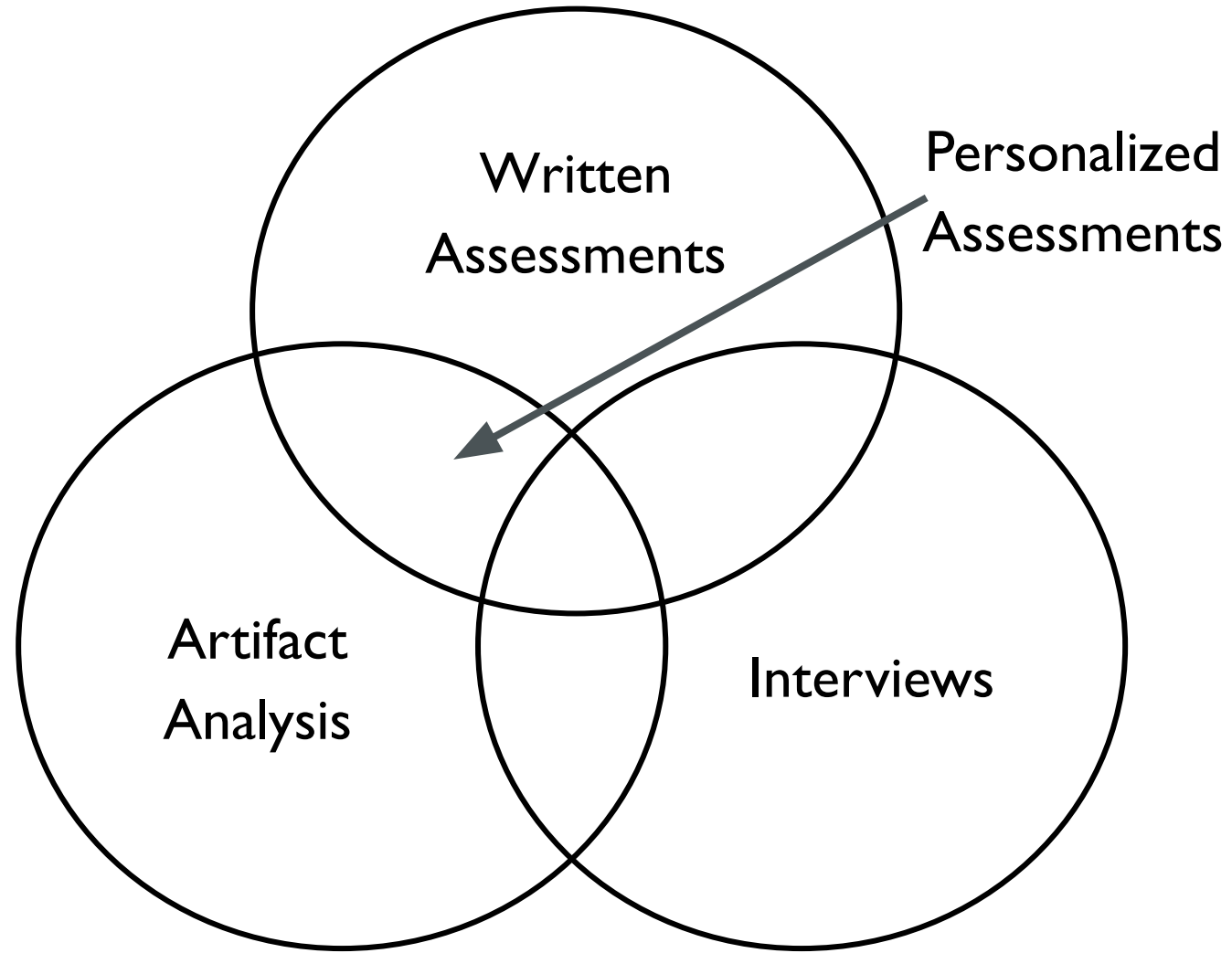
Written assessments:

- + Most expedient choice (Burke et al, 2012, Franklin et al., 2013, Gordon et al., 2012, Lewis et al., 2012, Meerbaum et al., 2013)
- Not many validated assessments for elementary computing

Interviews:

- + Most complete & personalized picture (Brennan et al., 2012)
- Prohibitively time-consuming

Personalized: Written assessments with Student Code



Asking students about their own code introduces an interesting conundrum.

Mystery Function

```
list = [26, 17, 89, 40]
for item in list:
    if item%2==0:
        print item
```

Student A

“It prints out the even numbers in the list.”

Student B

“It makes list equal to 26, 17, 89, & 40. For each item in the list, it checks if item modulo 2 equals zero. If yes, print.”

Outline

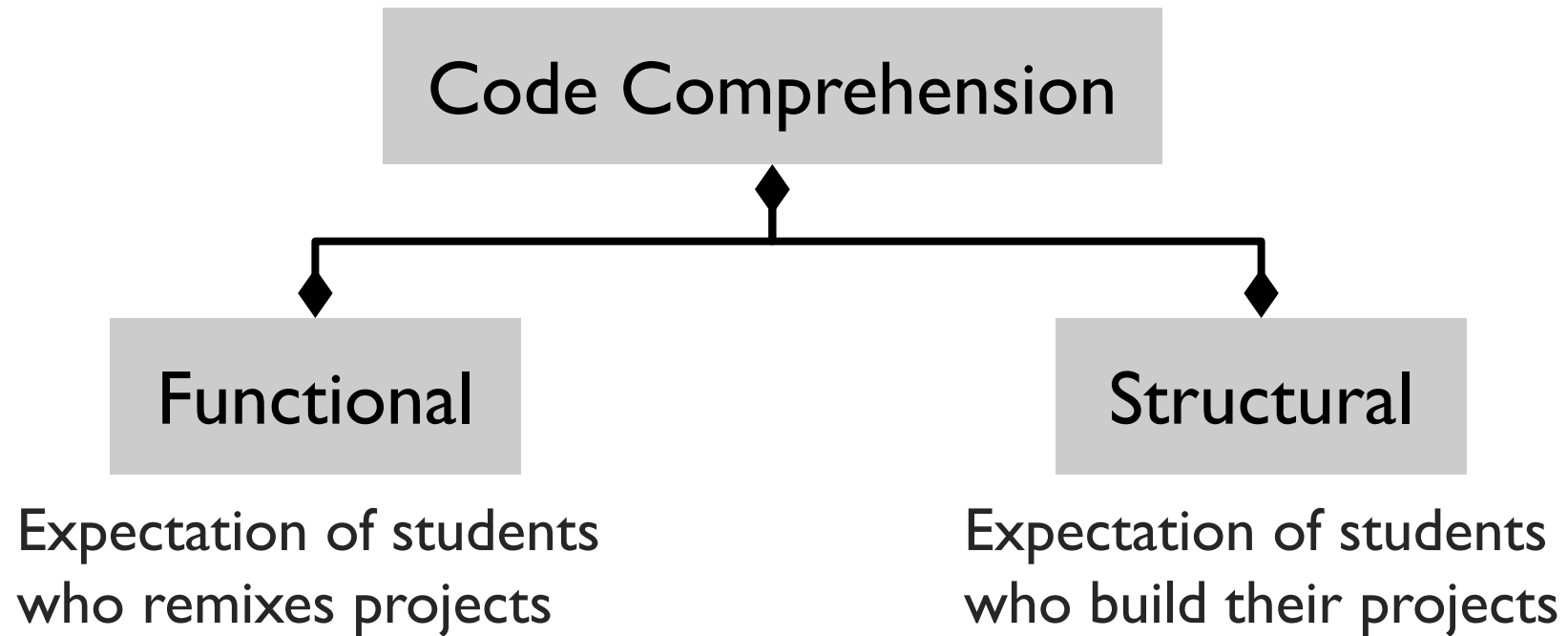
Motivation & Related Work

Theoretical Framework

Study Design

Results

Schulte's Block Model explains the types of code comprehension.



Asking students about their own code introduces a conundrum between structural & functional understanding.

Mystery Function

```
list = [26, 17, 89, 40]
```

```
for item in list:
```

```
    if item%2==0:
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PAWS Tool: Personalized Assessment Generation

“Personalized Assessment Worksheets for Scratch”

Start with a written assessment with generic code snippets

Searches Scratch projects for candidate code

“Candidate code”: Different requirements based on the question

Random assignment of personalized or generic code

Our study took place over 2 years in urban schools.

1st year: 316 4th-graders (ages 9-10)

2nd year: 329 3rd-5th graders (ages 9-12)

3 CT modules in Scratch: events, sequence, & loops

Assessment at the end of each module:

Guided by the Evidence-Centered Design framework

Domain analysis was guided by CS K-12 framework &

K-8 learning trajectories

Designed by CS & education researchers & practitioners

Quantitative Analysis: Big Picture

ANOVA F-test: Personalization influence on assessment scores
for those with candidate code.

p-value is the probability that results are by chance.

Type 3 Sum of Squares accounts for imbalance.

Qualitative analysis: Detailed Picture

Broke down results more fine-grained than scores

Personalized questions were cross-referenced with artifacts.

χ^2 test: Dependency between treatments & response categories.

Free-response questions: Kappa inter-rater reliability $\geq 80\%$.

Fisher's exact test: Proportion of personalized or generic responses with a specific attribute

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Research Question:

How does code source (generic or project) affect student answers?

No statistically-significant differences in performance scores

Patterns from more fine-grained, qualitative analysis:

When asked multiple-choice questions:

Individual blocks integrated into generic script

Whole scripts in project context

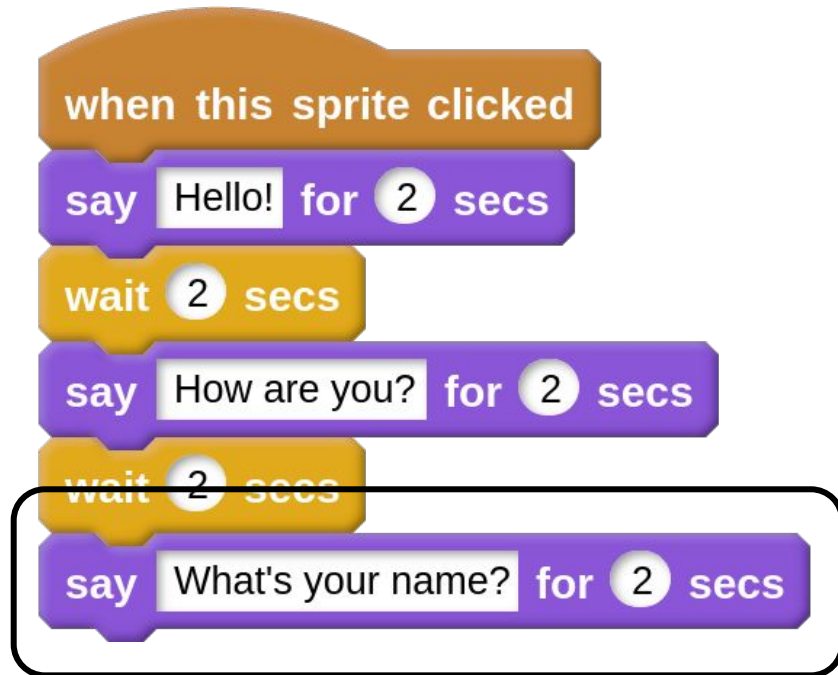
When asked open-ended questions:

Explain in Plain English questions

“when do you use loops” questions

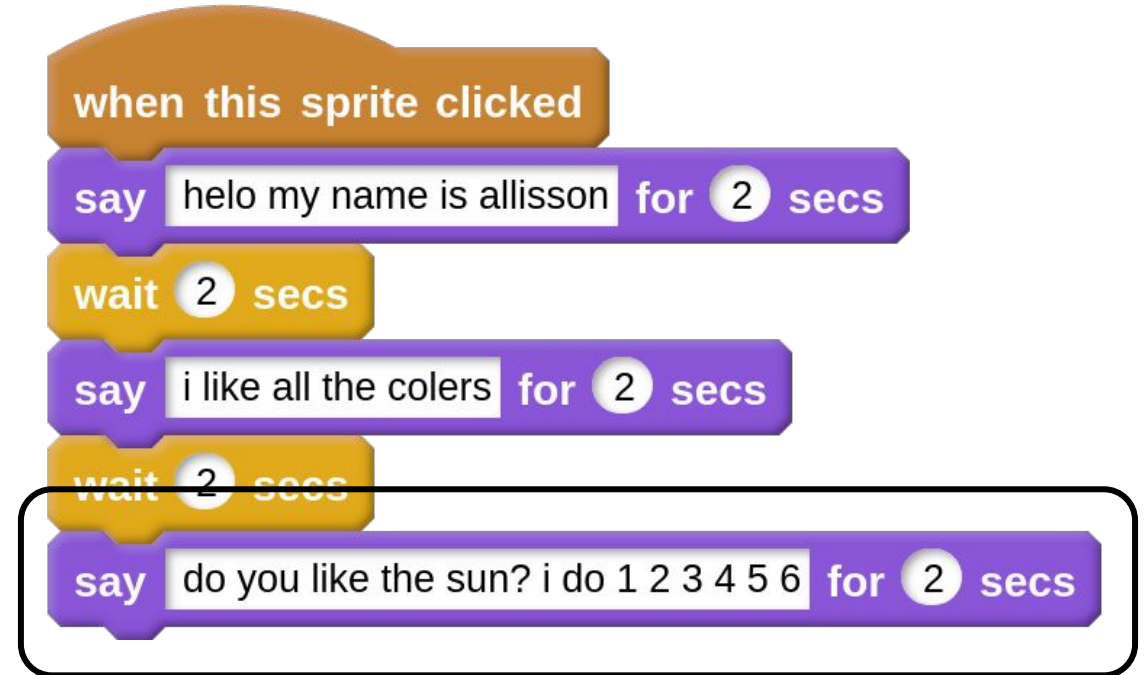
Integrating personalized “Say” blocks into the generic script

Question: Circle the “Say” block that will be run last.



A Scratch script starting with a brown 'when this sprite clicked' block. It contains four purple 'say' blocks and two yellow 'wait 2 secs' blocks. The 'say' blocks contain the text: 'Hello!', 'How are you?', 'What's your name?', and 'What's your name?'. The 'wait' blocks are placed between the first and second 'say' blocks, and between the third and fourth 'say' blocks. The final 'say' block, 'What's your name?', is circled in black.

Generic Code



A Scratch script starting with a brown 'when this sprite clicked' block. It contains four purple 'say' blocks and two yellow 'wait 2 secs' blocks. The 'say' blocks contain the text: 'helo my name is allisson', 'i like all the colers', 'do you like the sun? i do 1 2 3 4 5 6', and 'do you like the sun? i do 1 2 3 4 5 6'. The 'wait' blocks are placed between the first and second 'say' blocks, and between the third and fourth 'say' blocks. The final 'say' block, 'do you like the sun? i do 1 2 3 4 5 6', is circled in black.

Personalized Code

Individual blocks should not be taken out of context.

```
when this sprite clicked
say helo my name is allisson for 2 secs
wait 2 secs
say i like all the colers for 2 secs
wait 2 secs
say do you like the sun? i do 1 2 3 4 5 6 for 2 secs
```

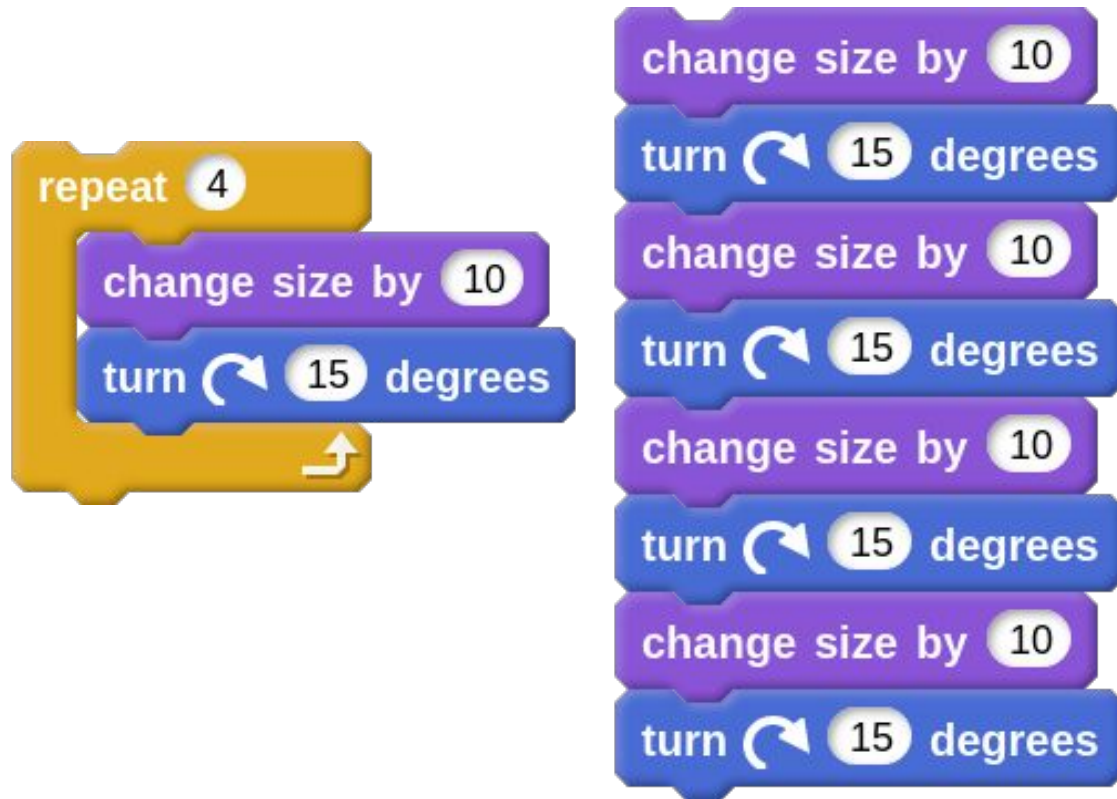
Personalized Code

Students who answered wrong circled last block *in their project*.

Blocks out of context triggered a mismatch between functional & structural understanding.

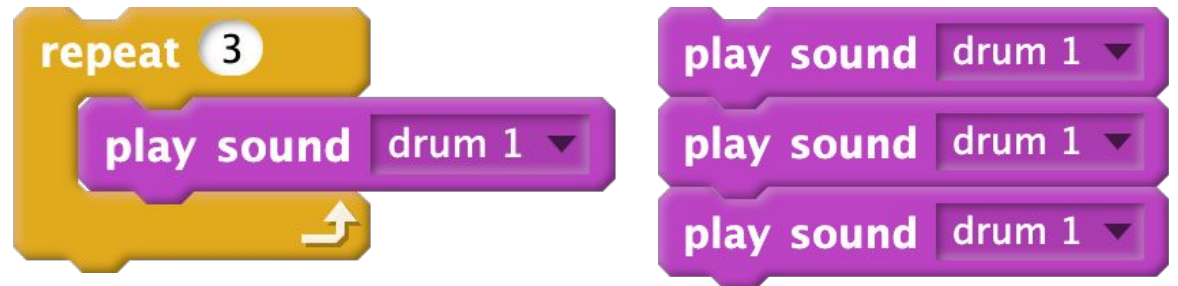
Unrolling a loop from their code

Similar performance between generic & personalized code



The 'Generic Code' block consists of a yellow 'repeat' block with the number '4'. Inside the loop, there are two blocks: a purple 'change size by 10' block and a blue 'turn 15 degrees' block. To the right of the loop, the same two blocks are repeated four times in a vertical stack, representing the unrolled code.

Generic Code

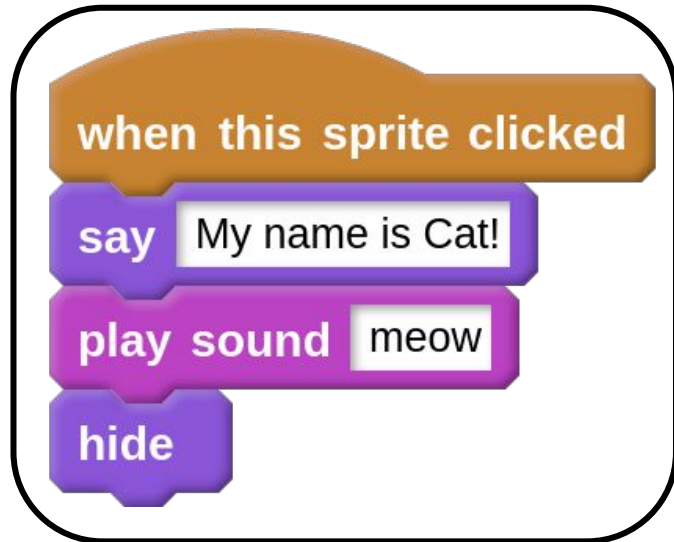


The 'Personalized Code' block consists of a yellow 'repeat' block with the number '3'. Inside the loop, there is one purple 'play sound drum 1' block. To the right of the loop, three identical 'play sound drum 1' blocks are stacked vertically, representing the unrolled code.

Personalized Code

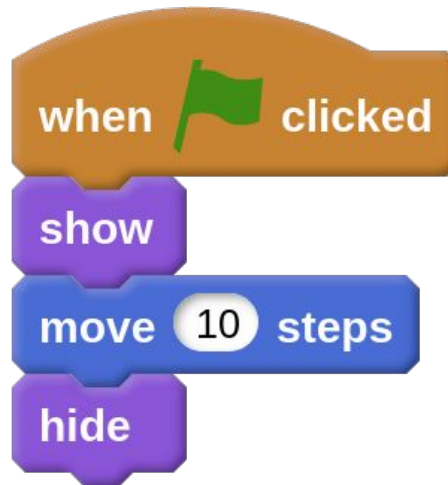
Swapping out generic scripts with personalized scripts

Question: Circle all the scripts that run when you click the sprite.

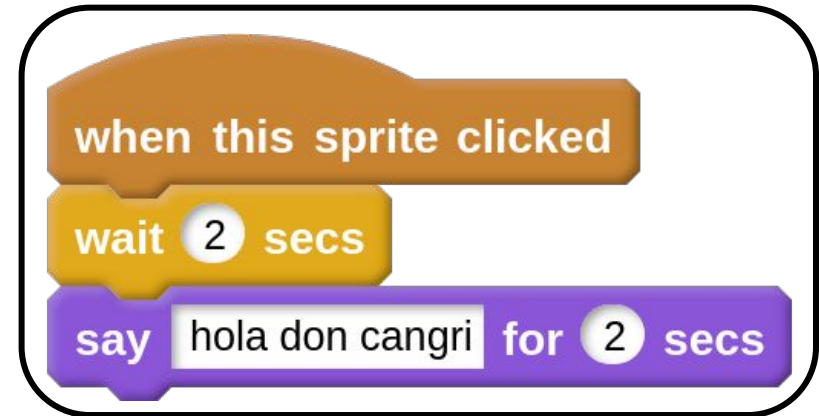


A script block titled "when this sprite clicked" containing three actions: "say My name is Cat!", "play sound meow", and "hide". This script is circled in black.

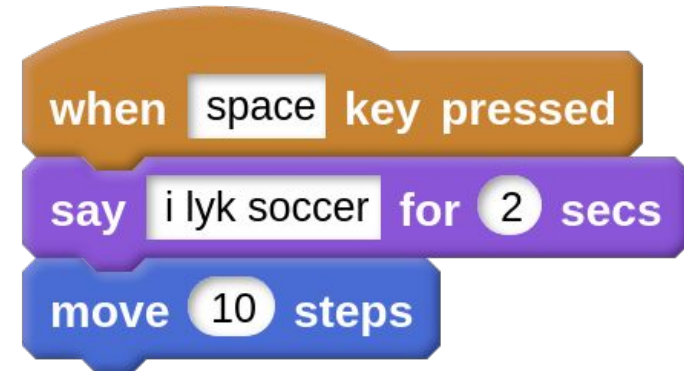
Generic Code



A script block titled "when clicked" (with a green flag icon) containing three actions: "show", "move 10 steps", and "hide".



A script block titled "when this sprite clicked" containing two actions: "wait 2 secs" and "say hola don cangri for 2 secs". This script is circled in black.



A script block titled "when space key pressed" containing two actions: "say i lyk soccer for 2 secs" and "move 10 steps".

Personalized Code

Students with personalized code were more likely to choose some or all correct options.

	All X	Some ✓ Some X	Some ✓ No X	All ✓ No X
Y1: Personalized	15.6%	9.0%	20.7%	54.1%
Y1: Generic	25.7%	13.3%	11.5%	49.6%
Y2: Personalized	15.3%	9.0%	3.6%	72.1%
Y2: Generic	23.7%	15.8%	0%	60.4%

We asked students about a script from their code.

Personalized Code

```
when space key pressed  
say kiki do u luv me for 2 secs  
move 10 steps  
next costume
```

Year 1 Open-Ended Structure:

What will this script make the sprite do?

Year 2 Scaffolded Structure:

What do you do to make the script run?

(different event options)

What will this script make the sprite do?

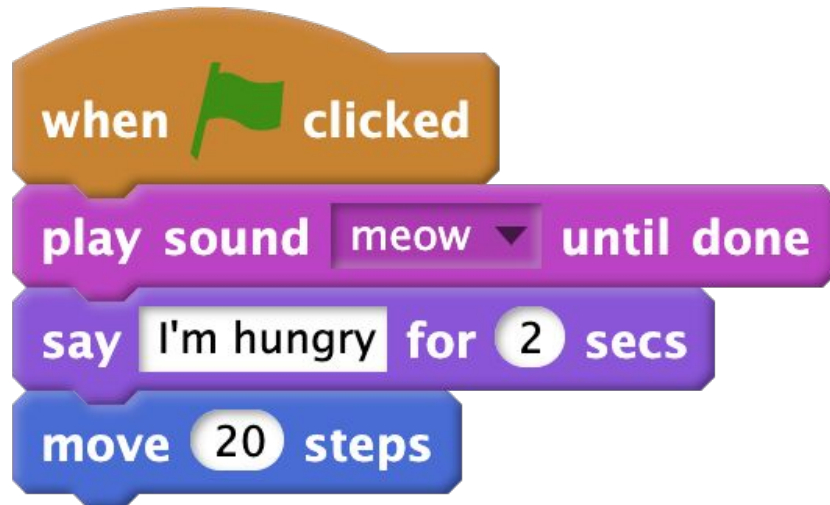
First, _____

Next, _____

Last, _____

Students with personalized code answered with a functional, not structural, answer.

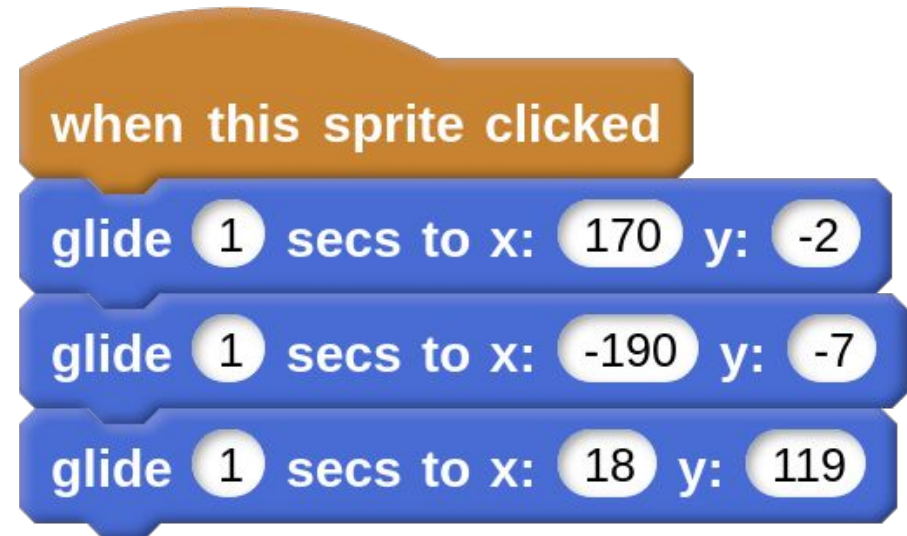
Generic Code:



Student Response:

“First, the sprite meows.
Next, it says ‘I’m hungry’
Last, it walks 20 steps.”

Personalized Code:



Student Response:

“It walks back and forth
then stops.”

Students were asked why they used a loop.

Generic

How do you know to use a loop?

Twice as likely to answer with the general purpose of a loop

Personalized

Why did you choose to use this loop?

How did you choose the number in the loop?

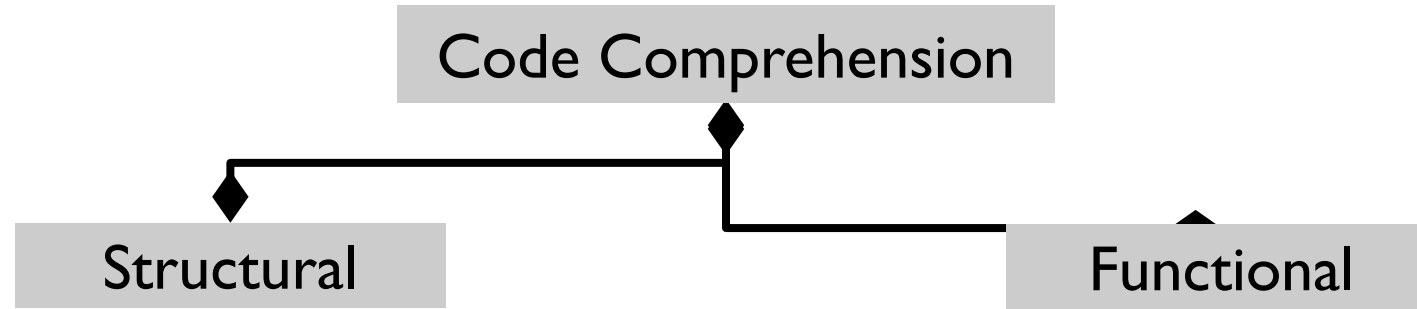
More likely to:

- cite a specific use of loops

- cite a benefit of using a loop

(e.g. saves time, shorter code)

The conundrum between the forms of understanding invites further study.



Asking about their own code challenges assumptions about EiPE questions.

Getting young students to articulate the different kinds of understanding is tricky.

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Let's continue the conversation!



Key Contributions:

New assessment technique --- integrating student code into written assessments

When asked about their own code, students answered:

some multiple-choice & fill-in-the-blank questions differently

free-response questions with a functional, instead of

structural understanding