Distractors in Parsons Problems Decrease Learning Efficiency for Young Novice Programmers

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Code Puzzle: Parsons Problems

csp-8-3-3: The following is the correct code for printing a countdown from 10 to 0, but it is mixed up. Drag the blocks from the left and put them in the correct order on the right. Don't forget to indent blocks in the body of the loop. Just drag the block to the further right to indent. Click the *Check Me* button to check your solution.



Parsons, D. and Haden, P. 2006. Parson's Programming Puzzles: A Fun and Effective Learning Tool for First Programming Courses. js-parsons - JavaScript library for Parson's Problems: https://js-parsons.github.io/

Code Puzzles & Distractors

csp-8-3-4: The following is the correct code for printing the even numbers from 0 to 10, **but it also includes some extra code that you won't need**. Drag the needed blocks from the left and put them in the correct order on the right. Don't forget to indent blocks in the body of the loop. Just drag the block to the further right to indent. Click the *Check Me* button to check your solution.



Parsons, D. and Haden, P. 2006. Parson's Programming Puzzles: A Fun and Effective Learning Tool for First Programming Courses. Ericson, B.J. et al. 2015. Analysis of Interactive Features Designed to Enhance Learning in an Ebook.

A Distractor is an *Error*...

csp-8-3-4: The following is the correct code for printing the even numbers from 0 to 10, **but it also includes some extra code that you won't need**. Drag the needed blocks from the left and put them in the correct order on the right. Don't forget to indent blocks in the body of the loop. Just drag the block to the further right to indent. Click the *Check Me* button to check your solution.



Learning with Errors: Teach Common Misconceptions

Print TRUE if string1 and string2 contain the same value.

```
String string1 = new String("abc");
String string2 = new String("abc");
if (string1 = string2) {
   System.out.println("TRUE");
} else {
   System.out.println("FALSE");
}
String string1 = new String("abc");
String string2 = new String("abc");
if (string1.equals(string2)) {
   System.out.println("TRUE");
} else {
   System.out.println("FALSE");
}
```

Muller, D. a. et al. 2008. Saying the wrong thing: improving learning with multimedia by including misconceptions. Große, C.S. and Renkl, A. 2007. Finding and fixing errors in worked examples: Can this foster learning outcomes? Wang, M. et al. 2015. Using Feedback to Improve Learning: Differentiating between Correct and Erroneous Examples.

Distractors in Multiple Choice Tests

1. Consider the following code segment.

```
String string1 = new String("abc");
String string2 = new String("abc");
if (string1 = string2) {
  System.out.println("TRUE");
} else {
  System.out.println("FALSE");
```



What is printed as a result of executing the code segment?

Roediger, H.L. and Karpicke, J.D. 2006. Test-Enhanced Learning Taking Memory Tests Improves Long-Term Retention.

Karpicke, J.D. 2012. Retrieval-Based Learning Active Retrieval Promotes Meaningful Learning. Roediger III, H.L. and Butler, A.C. 2011. The critical role of retrieval practice in long-term retention. Richland, L.E. et al. 2009. The pretesting effect: Do unsuccessful retrieval attempts enhance learning? Little, J.L. and Bjork, E.L. 2012. The persisting benefits of using multiple-choice tests as learning events. Roediger III, H.L. and Marsh, E.J. 2005. The Positive and Negative Consequences of Multiple-Choice

Testing & Information Retrieval



1. Consider the following code segment.

```
String string1 = new String("abc");
String string2 = new String("abc");
```

```
if (string1 = string2) {
   System.out.println("TRUE");
} else {
   System.out.println("FALSE");
}
```

(b) FALSE

(c) TRUE

FALSE

What is printed as a result of executing the code segment? (a) TRUE

The Testing Effect

1. Consider the following code segment.

```
String string1 = new String("abc");
String string2 = new String("abc");
```

```
if (string1 = string2) {
   System.out.println("TRUE");
} else {
   System.out.println("FALSE");
```

What is printed as a result of executing the code segment?

(c) TRUE FALSE

(b) FALSE

(a) TRUE

Bridger, E.K. and Mecklinger, A. 2014. Errorful and errorless learning: The impact of cue–target constraint in learning from errors. Roediger, H.L. and Karpicke, J.D. 2006. Test-Enhanced Learning Taking Memory Tests Improves Long-Term Retention. Karpicke, J.D. 2012. Retrieval-Based Learning Active Retrieval Promotes Meaningful Learning.

Distractors in Code Puzzles...





What is a distractor in a code puzzle?

What is the impact of distractors in code puzzles?

What is a Distractor in a Code Puzzle?

"Unnecessary Code"

"Extra Fragments"

"Erroneous Code"

Distractors can be used to...

"illustrate a particular point"

"highlight programming principles the student may ignore"



Parsons, D. and Haden, P. 2006. Parson's Programming Puzzles: A Fun and Effective Learning Tool for First Programming

Formative Evaluation

16 participants (10 to 15 years)

10 female, 6 male

Average age: 11.9 years



Harms, K.J. et al. 2015. Enabling independent learning of programming concepts through programming completion puzzles.

Partial, Suboptimal Path Distractors

Initial State

Initial Nesting

Alternative Statements

Initial State Distractor

Whack-a-Yeti - Looking Glass (2) ×			
Play Correct Play Mine tiny yeti shrink big yeti take a bow Repeat (2) times Do together Do together Do together Ioop tiny yeti jung tiny yeti	Whack-a-Yeti - Looking Glass (2) x Image: Contract of the cont		
tinyyeti jump and grow (2.0)			
big yeti) drop hammer			

Initial State Distractor: Solution

Whack-a-Yeti - Looking Glass (2)			
Play Correct Play Mine	Whack-a-Yeti - Looking Glass (2)		
Do together Repeat 2 times	big yeti arop nammer tinyyeti jump and grow 2.0 tinyyeti take a bow big yeti take a bow		

Initial Nesting Distractor

Shark Snack - Looking Glass (2)			
	 S Undo C Redo m Reset X Qu The animation, Shark Snack, is all mixed up! Using only the pieces you need, put the animation back in the correct order. 	iit	
* 5	Drop action here.		
Play Correct Play Mine			
Shark close mouth Shark move to fish animationStyle BEC Do together Shark sneak up on fish Shark sneak up on fish Shark turn to face fish Shark open mouth fish turn around Repeat (4) times			
fish swim forward			

Initial Nesting Distractor: Solution

Shark Snack - Looking Glass (2)			
	S Undo C Redo 🛱 Reset 🗙 Quit		
 Play Correct Play Mine 	The animation, Shark Snack, is all mixed up! Using only the pieces you need, put the animation back in the correct order.		
	Shark turn to face fish fish turn to face shark shark open mouth shark move to fish animationStyle (BEGIN GENTLY AND END ABRUPTLY) shark close mouth		
Repeat (a) times Shark sneak up on fish loop			

Alternative Statement Distractor

Monkey Business - Looking Glass (2)			
Play Correct Play Mine Play Correct Play Mine Creven monkey jump forward Repeat 2 times Joop Repeat 2 times Joop Grey monkey hop side to side Grey monkey hop side to side Grey monkey lay down Crown monkey turn around Drown monkey turn around	Undo C Redo Reset X Quit The animation, Monkey Business, is all mixed up! Using only the pieces you need, put the animation back in the correct order. grey monkey jump onto couch grey monkey move arms up and down brown monkey move arms up and down grey monkey move arms up and down grey monkey move arms up and down		

Alternative Statement Distractor: Solution

Research Questions

What is a distractor in a code puzzle?

What is the impact of distractors in code puzzles?

- Do participants use the distractors?
- How do distractors affect task completion time, task success, and cognitive load?
- Do distractor participants show more evidence of learning?

Summative Evaluation

92 participants (10 to 15 years)

32 female, 60 male

Average age: 12.9 years

Between-Subjects

Yeti Baseball - Looking Glass		
A	5 Undo C Redo 💼 Reset 🗙 Quit	:
	The animation, Yeti Baseball, is all mixed up! Using only the pieces you need, put the animation back in the correct order.	
Play Correct Play Mine	tiny yeti turn to face big yeti Do together big yeti nod tiny yeti nod tiny yeti tiny yeti move BACKWARD 0.5 meters	
tiny yeti jump to hammer		
big yeti power swing Do together big yeti wind up swing		

Study Design: Training Phase



Transfer Phase



Training Tasks

Task	Programming Concept	Partial Suboptimal Path Distractors	
1	Do Together	Alternative Statements	
2	Repeat	Alternative Statements × 2	
3	Repeat { Repeat }	Initial State Alternative Statements	
4	Repeat { Repeat }	Initial State Alternative Statements	
5 Repeat { Do Together }		Initial State Initial Nesting	
6	Do Together { Repeat }	Initial Nesting Alternative Statements	

Training Task: Conditions



No Distractors

Distractors

Study Design: Transfer Phase



Transfer Tasks

Programming Concepts:

Repeat { Do Together }
Do Together { Repeat }
Repeat { Repeat }

task.lgp - Looking Glass (1)		
World Edit Help		
Bave → Undo ← Redo > Play		
Coconut (6) Coconut (6) straighten out joints Action Ordering Boxes	Scene Hungry Monkey custom action Hungry Monkey monkey jump forward monkey look up Instructions • The monkey should climb the palm tree, twice. • The monkey should climb the palm tree, twice. • The monkey should climb the palm tree, twice. • The monkey should shake the palm tree and it should drop 3 coconuts, twice. • To complete this, you may add up to 3 additional actions or action ordering boxes. monkey climb thing : palm tree this palm tr	
Do actions in order, one at a time Do in order Do actions at the same time Do together Repeat actions multiple times Repeat number times loop Repeat while condition loop		

Initial State

Transfer Task Instructions

	task.lgp - Looking Glass (1)	×	
World Edit Help			
🛓 Save 🌗 Undo 🗬 Redo 🕞 Play	🗙 Do	one	
	Scene Hungry Monkey		
	custom action Hungry Monkey	_	Task Instructions X
	monkey jump forward monkey look up Instructions		 Try your best to make your animation match the correct animation below. All of the existing actions are already in the correct order. You may only add up to 3 additional actions or action ordering boxes total.
Coconut (6) Coconut (6) straighten out joints Action Ordering Percent	 The monkey should climb the palm tree, twice. Then the monkey should shake the palm tree and it should drop 3 coconuts, twice. To complete this, you may add up to 3 additional actions or action ordering boxes. monkey v climb thing : [palm tree v] [monkey] v shake thing : [palm tree v] [palm tree v] drop coconut 		
Action Ordering Boxes Do actions in order, one at a time Do in order Do actions at the same time Do together Repeat actions multiple times Repeat number times loop	[monkey]* drop down		
Repeat while condition loop			

Completed Transfer Task



Completed Task

Research Questions

Do participants use the distractors?

How do distractors affect task completion time, task success, and cognitive load? Do distractor participants show more evidence of learning?

Research Questions

Do participants use the distractors?

How do distractors affect task completion time, task success, and cognitive load?

Do distractor participants show more evidence of learning?

Distractors Increased Puzzle Time-on-Task

Average Puzzle Time-on-Task



Distractor Participants Completed Fewer Puzzles Successfully

Percentage of Participants Who Successfully Completed Each Puzzle



32

Distractors Increased Cognitive Load when Completing Puzzles

Mean Mental Effort Rating for Each Puzzle



Morrison, B.B. et al. 2014. Measuring Cognitive Load in Introductory CS: Adaptation of an

Research Questions

Do participants use the distractors?

How do distractors affect task completion time, task success, and cognitive load? Do distractor participants show more evidence of learning?

> Distractors... Increased time on task Decreased puzzle success Increased extraneous cognitive load

Research Questions

Do participants use the distractors?

How do distractors affect task completion time, task success, and cognitive load?

Do distractor participants show more evidence of learning?

No Difference in Transfer Task Performance

Percentage of Participants Who Successfully Completed Each Transfer Task



Research Questions

Do participants use the distractors?

How do distractors affect task completion time, task success, and cognitive load?

Do distractor participants show more evidence of learning?

When looking for evidence of learning, we found no difference between distractor and control participants.

Instructional Efficiency



Paas, F.G.W.C. and Merriënboer, J.J.G.V. 1993. The Efficiency of Instructional Conditions: An Approach to Combine Mental Effort and Performance Measures.

Summary



We found no evidence that distractors promote learning.

Further, distractors increased learners' cognitive load, decreased their success at completing code puzzles by 26%, and also increased their time on task by 14%.



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