Couplets: Helping Elementary School Students Recognize Structure in Code

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Abstract

For several years we've been working on teaching elementary school students to reason about programs [1-2]. We believe that teaching this kind of reasoning is as important as teaching students to write programs.

Prior research shows that students often have challenges reasoning about programs and need scaffolds [3]. Thus, to facilitate development of this cognitive skill in young children it is important to choose the right domain and provide appropriate supports.

We use Kodu Game Lab because one can write interesting, non-trivial programs in two to four lines, Prior work shows that analyzing these programs is within the abilities of a typical 8-11 year old [4].

In this poster we describe *Couplets*, a diagramming technique for analyzing Kodu programs to reveal the presence of an important design pattern called Pursue and Consume. Using our novel technique to uncover this pattern leads to accurate predictions of program behavior, or uncovering of bugs if the pattern is not fully realized.

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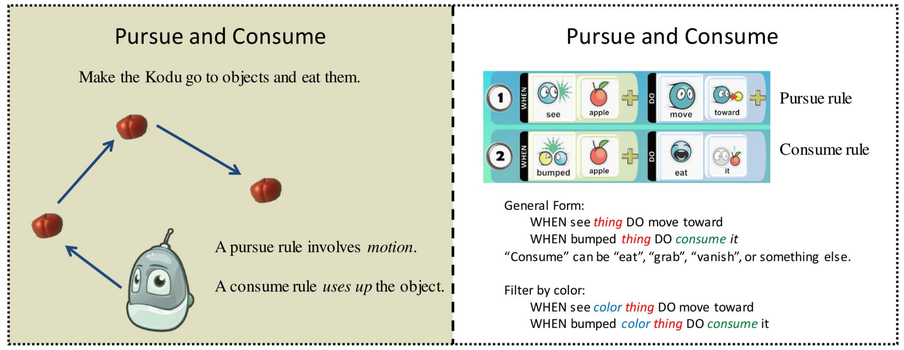
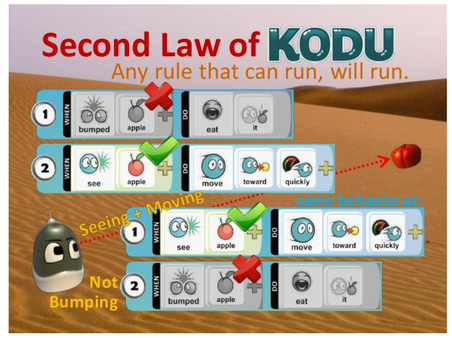
Reasoning about programs requires students to understand the structure of code

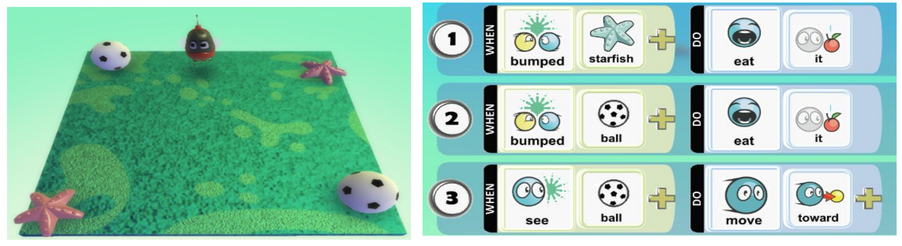
Recognizing Design Patterns within Programs



Applying Laws to Understand & Predict Behavior of Programs

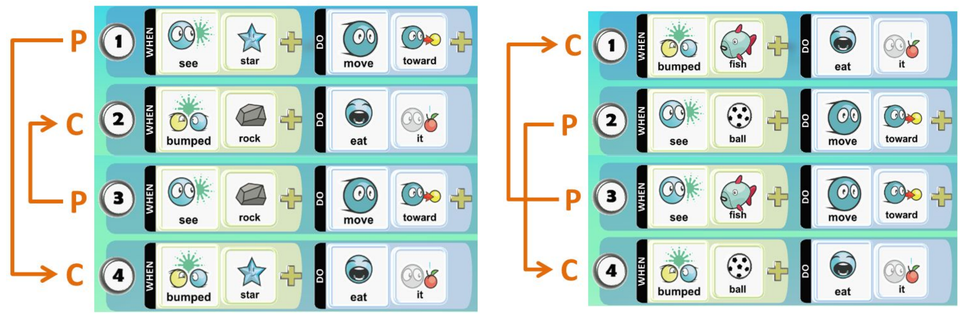


What will the Kodu eat first? When will the Kodu eat a starfish?



Couplets Procedure

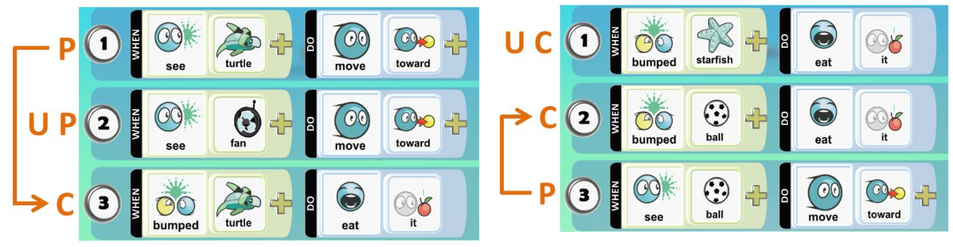
1. Label all Pursue Rules *"P"* and all Consume Rules *"C"*
2. Draw arrows from each *P* to the corresponding *C*
3. Find any rule that isn't paired; place a U in front of the rule letter
   e.g, UP - Unpaired Pursue or UC - Unpaired Consume



Reasoning

★ First rule labeled with a P or UP identifies the first object pursued, *no matter what rules come before or after that rule*

★ No other Pursue rule will run until all of the first pursued objects are consumed



★ UP - Unpaired Pursue Rule
⇨ Stuck character
Kodu will go to an object and get stuck

★ UC - Unpaired Consume Rule
⇨ Consumer starves
Unless fed, consume rules can't run.

Results

★ In a study of 40 third graders learning Kodu who were given brief instruction in the couplets technique, we found that they were able to apply it to 3-4 line programs and achieve correct response rates of roughly 85% for prediction questions.

★ Our results suggest that elementary school children can learn to reason abstractly about programs if given the right mental tools.

References:

[1] Touretzky, D. S., Gardner-McCune, C., and Aggarwal, A. (2016) Teaching 'lawfulness' with Kodu. *Proceedings of SIGCSE '16*, Memphis, TN. Association for Computing Machinery.

[2] Touretzky, D. S., Gardner-McCune, C., and Aggarwal, A. (2017) Semantic reasoning in young programmers.*Proceedings of SIGCSE '17*, Seattle, WA. ACM.

[3] Lister, R., Fidge, C., and Teague, D. (2009) Further evidence of a relationship between explaining, tracing and writing skills in introductory programming. In Proceedings of the 14th annual ACM SIGCSE conference on Innovation and technology in computer science education (ITiCSE '09). ACM. p. 161-165.

[4] Aggarwal, A., Touretzky, D. S., and Gardner-McCune, C. (2018) Demonstating the ability of elementary school students to reason about programs. *Proceedings of SIGCSE '18*, Baltimore, MD. ACM.