Expressing Computer Science Concepts Through Kodu Game Lab

Kathryn T. Stolee Teale Fristoe

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Challenge

Learning to program is hard

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Teaching programming is hard, too

Motivation

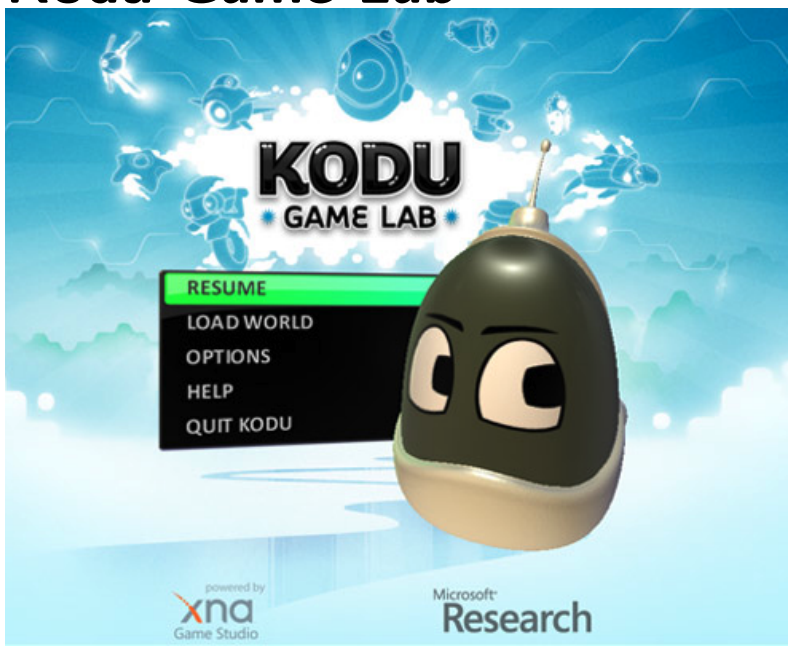
Educational Programming Languages:

- Useful to introduce novices to programming
- Commonly used in a classroom setting
- Used to create video games, simulations, animations, art ...
- Focus is on ease-of-use and attractiveness
- Many examples: Alice, Greenfoot, Scratch ...

About Kodu

- A video game for creating 3d video games
- Designed to compete with modern console games
- Available on Xbox or PC
- Uses an Xbox controller as the interface for playing and programming
- 110,000+ installs in 150+ countries

Kodu Game Lab



Microsoft FUSELABS

University of Nebraska Lincoln

University of California Santa Cruz

How Kodu is Different

- Integrates common gaming concepts (e.g., scoring, camera positioning, termination conditions)
- Programming model does not resemble syntax and abstraction level of mainstream languages

Kodu World

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Kodu World

Little is known about how skills learned in Kodu may transfer to more traditional languages

Interacting with Kodu

Play Mode

- Play the game
- Test or simulate programming logic

Edit Mode

- Modify terrain and objects
- Program characters

Interacting with Kodu

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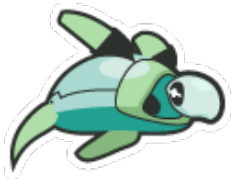
Kodu

Tree

Turtle



Apple

Programming: Kodu Language

- Language is a high-level, visual, and event-driven
- Statements take the form of 'When – Do' clauses

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Rule $\rightarrow$ Condition Action

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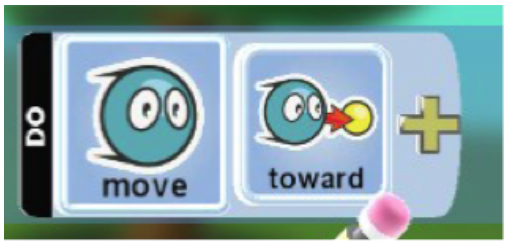

Rule $\rightarrow$ Condition **Action**

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Rule $\rightarrow$ **Condition Action**

Programming: User Perspective

- Programming involves visual composition of tiles

Programming: Rule Prioritization

- Rules are ordered and organized into pages
- Conflicting rules resolve action using order

Conflicting Rules

Programming: Page Usage

- Characters can have up to 12 pages of programming
- Switching pages changes character behavior (e.g., a power-up)

Big Question

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Can traditional computer science concepts (e.g., boolean logic, objects, variables, iteration, control flow) be expressed in Kodu?

Research Questions

RQ1: Which computer science concepts can be expressed through the Kodu Language?

RQ2: How often does each computer science concept appear in the programs created by the Kodu community?

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Analysis of ∼350 Kodu Programs

CS Concepts in Kodu

Obviously Supported:

- Objects: Encapsulation, Creation, Deletion
- Control Structures: if – then, iteration
- Variables: Global, Local, Random
- Boolean Logic: Negation

Subtly Supported:

- Objects: Cloning (class system)
- Boolean Logic: Conjunction, Disjunction
- Control Flow: Cycles, Fan-in, Fan-out

Yet to be Investigated:

- Function calls
- ...

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Boolean Logic: Negation

```
not A
```

Boolean Logic: Negation

`not A`

```
1 when A do B
2 when not A do C
```

Boolean Logic: Negation

`not A`

1 `when A do B`

2 `when` **`not A`** `do C`

Boolean Logic: Conjunction

- Condition
- Action

```
1 when A do B
    2 when C do D
    3 when always do E
```

Boolean Logic: Conjunction

- **Condition**

  $A \wedge C \Rightarrow D$

- Action

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    2 when C do D
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Boolean Logic: Conjunction

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- **Action**

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Boolean Logic: Conjunction

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- Action

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Boolean Logic: Disjunction

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$$\mathtt{A} \vee \mathtt{C} \Rightarrow \mathtt{B}$$

```
1 when A do B
2 when C do B
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Boolean Logic: Disjunction

$\mathtt{A} \vee \mathtt{C} \Rightarrow \mathtt{B}$

1 when **A** do **B**

2 when **C** do **B**

Expressions of Control Flow

- Pages represent character state in terms of behavior
- Switching pages can create non-linear program flow

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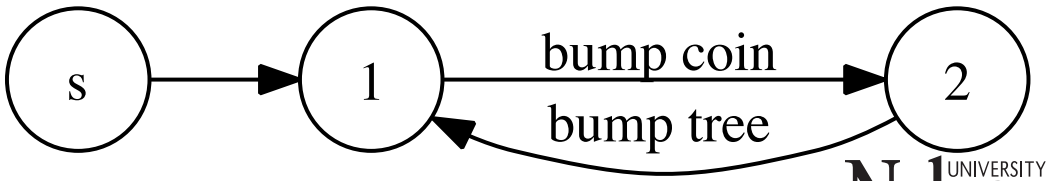
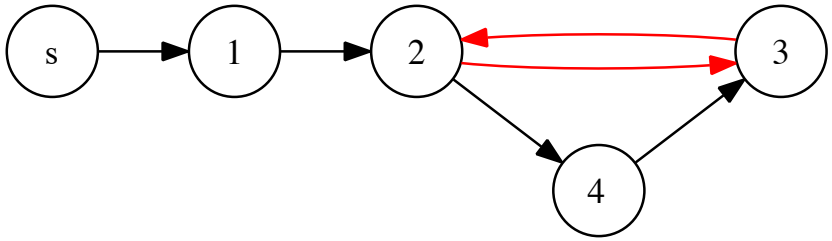


Control Flow Patterns

Cycles (iteration)



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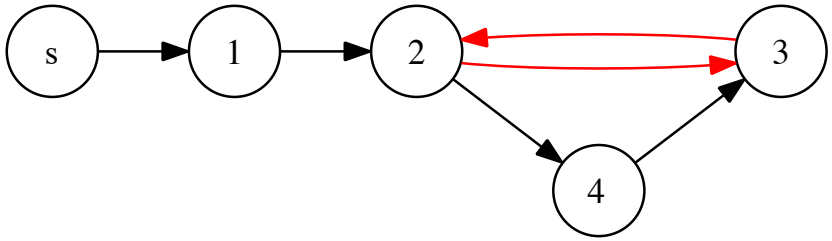
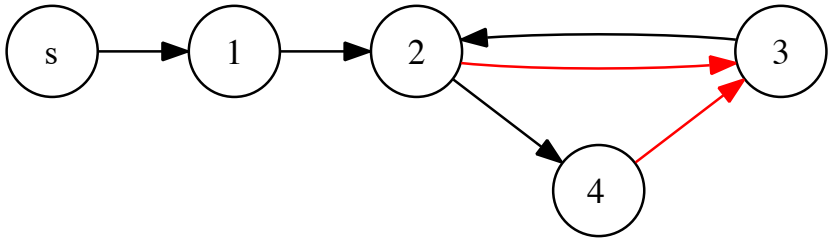


Fan-in (reuse)



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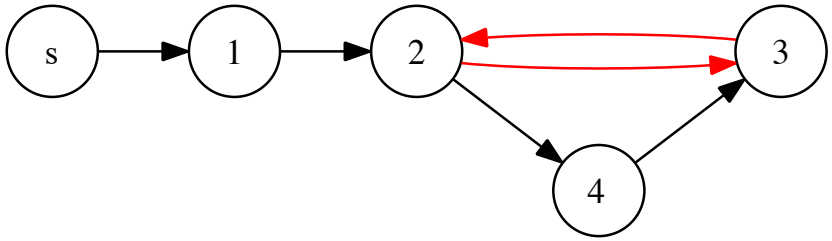

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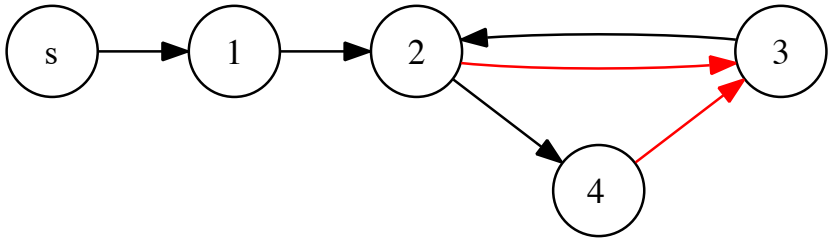
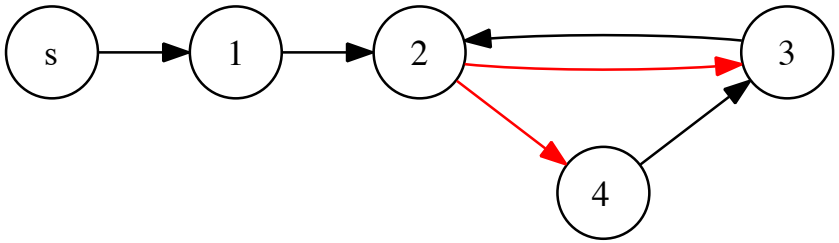


Fan-out (conditional flow)



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Profile for Kodu Program

346 programs from the XBox community (13 months of data)

Property	**Average**	**Median**
Rules	109	54
Total Tiles	497	231
Programmed Characters	18	12

Boolean Logic in the Community

CS Concept	**# Games**	**% Games**
Logical *Not*	61	17.6%
If-Then-Else Statements	29	8.4%
Logical *And* Condition[1]	17	20.9%
Logical *And* Action[1]	13	16.0%
Logical *Or*	208	59.9%

[1]The indentation feature needed for the logical *and* was introduced on March 19, 2010. These values consider only the 81 (23.4%) games published after that date.

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Control Flow in the Community

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2+ States	202	58.4%
Cycles	166	47.9%
Fan-in > 1	174	50.3%
Fan-out > 1	123	35.5%

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Threats to Validity

Internal Relationship between *expressing* concepts in code and *learning* those concepts is unverified.

External Programs were self-selected for uploading to Xbox community and may not be representative of the broader population.

Conclusion

What We Learned:

- Many fundamental computer science concepts *can* be expressed in Kodu
- Users make extensive use of the language and complex language constructs

Questions Left Unanswered:

- Are Kodu users internalizing the computer science concepts that appear in their games? (Requires evaluation)
- Can Kodu be used to teach computer science?

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