Comparing Textual and Block Interfaces in a Novice Programming Environment

Thomas Price
Tiffany Barnes

North Carolina State University

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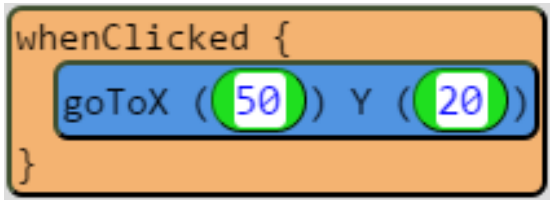
Block-Based Programming Environments

"Environments that allow users to construct and execute computer programs by composing atomic blocks of code together to produce program structure."



Motivation

- Block-based environments are becoming popular for teaching novices
- These environments are successful
  - Known for being *accessible* and *engaging*
  - E.g. Scratch, Alice, Snap, MIT App Inventor, LEGO Mindstorms
- They include (at least) two important features:
  - They use visual, drag-and-drop block programming
  - They are media-rich, connect students with interests
- Which features are important for this success?
  - Specifically, does the block interface make a difference?

Example - *Scratch*

- Designed to be more tinkerable, meaningful and social than past environments (Resnick et al. 2009)
- Graphical output centers around programmable sprites
- Used to make games, animations, music videos
- 25th most popular programming language (TIOBE Index, Jun. 2015)

Example - *Scratch*

Evaluations:

- A semester-long course with Scratch significantly improved 9th graders' test scores on most CS concepts (Meerbaum-Salant et al. 2013)
  - Students struggled with initialization, variables and concurrency
- Scratch was a popular choice in an urban after-school center (Maloney et al. 2008)
  - Students used Scratch voluntarily, without instruction
  - 50% used loops and user interaction
  - 25% used conditionals and concurrency
- Video game making with Scratch can "provide a rich context for programming" (Peppler & Kafai 2007)

Comparing Interfaces

- Students learning Scratch and Logo had similar, but not identical outcomes (Lewis 2010)
  - Logo users reported higher confidence afterwards
  - Scratch users did better on conditional test questions
  - Both groups gave similar difficulty ratings
- Comparing Modkit and Java users learning to program Arduino, Modkit users completed more activities (Booth & Stumpf 2013)
  - Modkit users reported lower perceived workload and more positive user experience

Comparing Interfaces

- From an HCI perspective, block and textual languages support different programming tasks better (McKay & Kölling 2013)
  - Block languages had differing strengths
- Students can transfer skills learned in a block language to a textual language (Wagner et al. 2013; Dann et al. 2012)
  - Facilitated by matching APIs
  - Students bridging from Alice to Java performed an average of 1 letter grade higher on a Java test than students learning only Java

Research Questions

When compared to a textual interface,

how will a block interface:

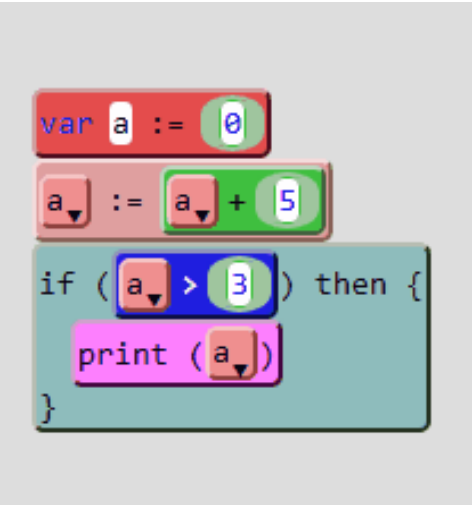
1. Affect students' attitudes towards computing?
2. Affect their perceived difficulty of programming?
3. Affect their performance on a programming activity?

Procedure Overview

- Modified an environment to directly compare block and textual interfaces
- Adapted an "Hour of Code" activity
- Collected data from two groups of students as they completed the activity, one with each interface
  - Pre-survey
  - Programming activity lasted 45 minutes
  - Post-survey
- Data collected and analyzed

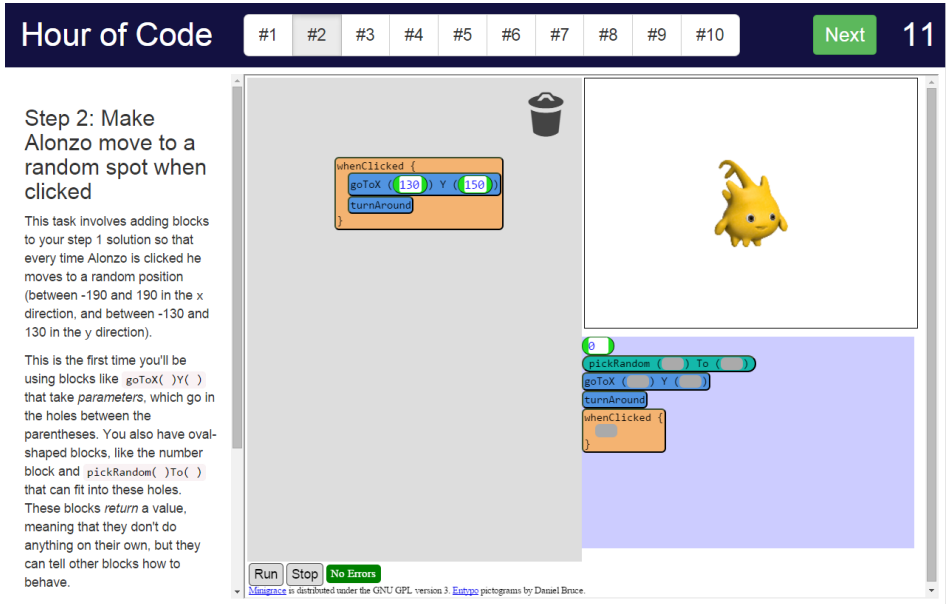
Tiled Grace

- Supports both "tiled" (block) and textual interfaces (Homer & Noble 2014)
  - Participants were locked into one interface or the other
- Original language designed for novice programmers
- Block interface very similar to Scratch



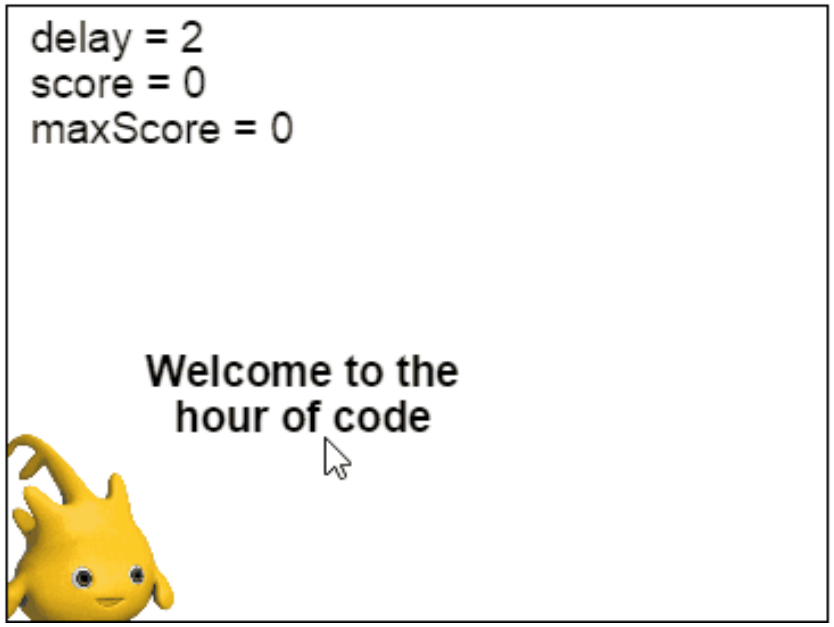
The Environment

- Created two versions of Tiled Grace, locked into one interface
- Embedded in a tutorial environment



The Activity

```
1  dialect "hoc"
2
                        Goals:  1 2 3 4 5 6 7 8 9
   var delay := 2       Colors:
   var score := 0
   var maxScore := 0
   whenClicked {
       say ""
       delay := delay - 0.1
       score := score + 10
       if (maxScore < score) then {
           maxScore := score
           clear
       }
       forever {
           goToX( pickRandom (-190) To (190) )
                Y ( pickRandom (-130) To (130) )
           turnAround
           if (score > 0) then {
               score := score - 1
           }
           wait (delay)
       }
   }
24
25 goToX (-190) Y (130)
   say ("Welcome to the hour of code")
   penDown
```



Participants

- Two classes from SPARCS, a middle school CS outreach program (Cateté et al. 2014)
  - No students from previous years
- 6th grade assigned to block interface
  - N=17: 12 male, 5 female
- 7th grade assigned to textual interface
  - N=14: 11 male, 3 female
- Condition assignments were random and groups were found to be similar populations
  - Block group had higher interest ratings on pre-survey

Data Collected

Pre-survey

- 4 Likert items to assess **Efficacy** w.r.t. CS
- 3 Likert items to assess **Interest** in computing
- 3 code evaluation (**Knowledge**) questions

Logs

- Complete code snapshots were saved at regular intervals and at each run

Post-survey

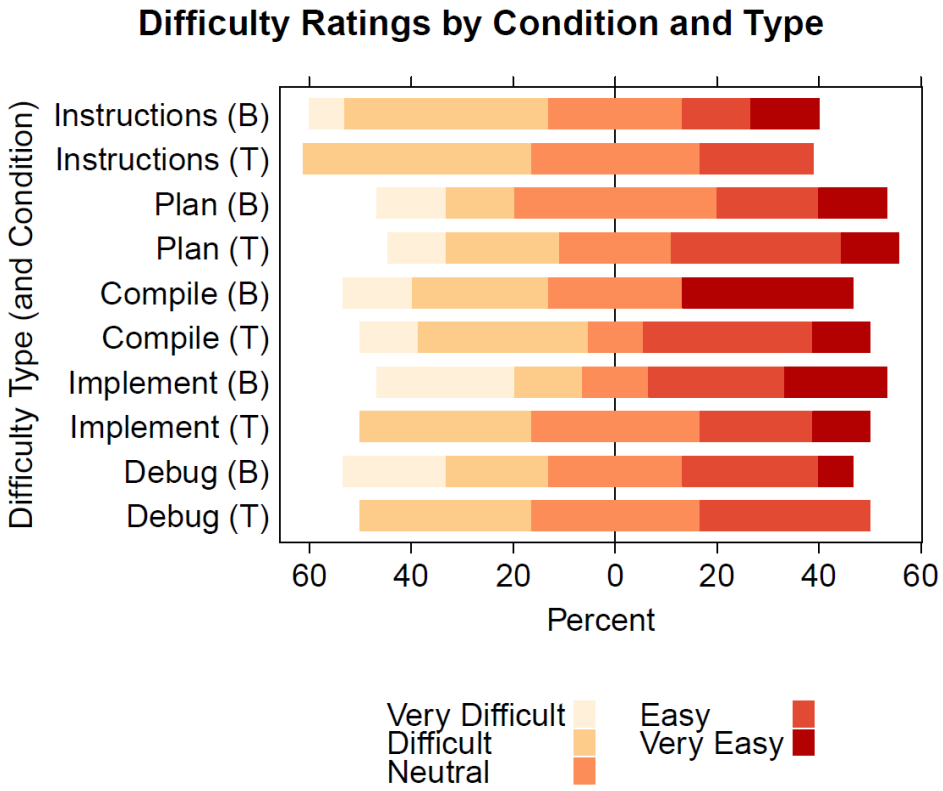
- Repeated pre-survey questions
- Users rated the difficulty of the activity

Survey - Attitudes

- **Efficacy** ratings significantly improved after the activity
  - The individual Likert items had contradictory results
- This effect was not significantly different between conditions
- There was no significant change in **Interest** ratings or **Knowledge** scores

Survey - Difficulty

- Students reported very similar difficulty across conditions, for each category



Survey - Dropout

- Some students in both groups dropped out of the post-survey
  - These students were omitted in pre/post survey comparisons
- These students may have been among the least engaged, possibly covering up a difference between conditions

	Pre-survey	Difficulty	Efficacy/Interest	All
Block	17	15	13	10
Text	14	9	9	7

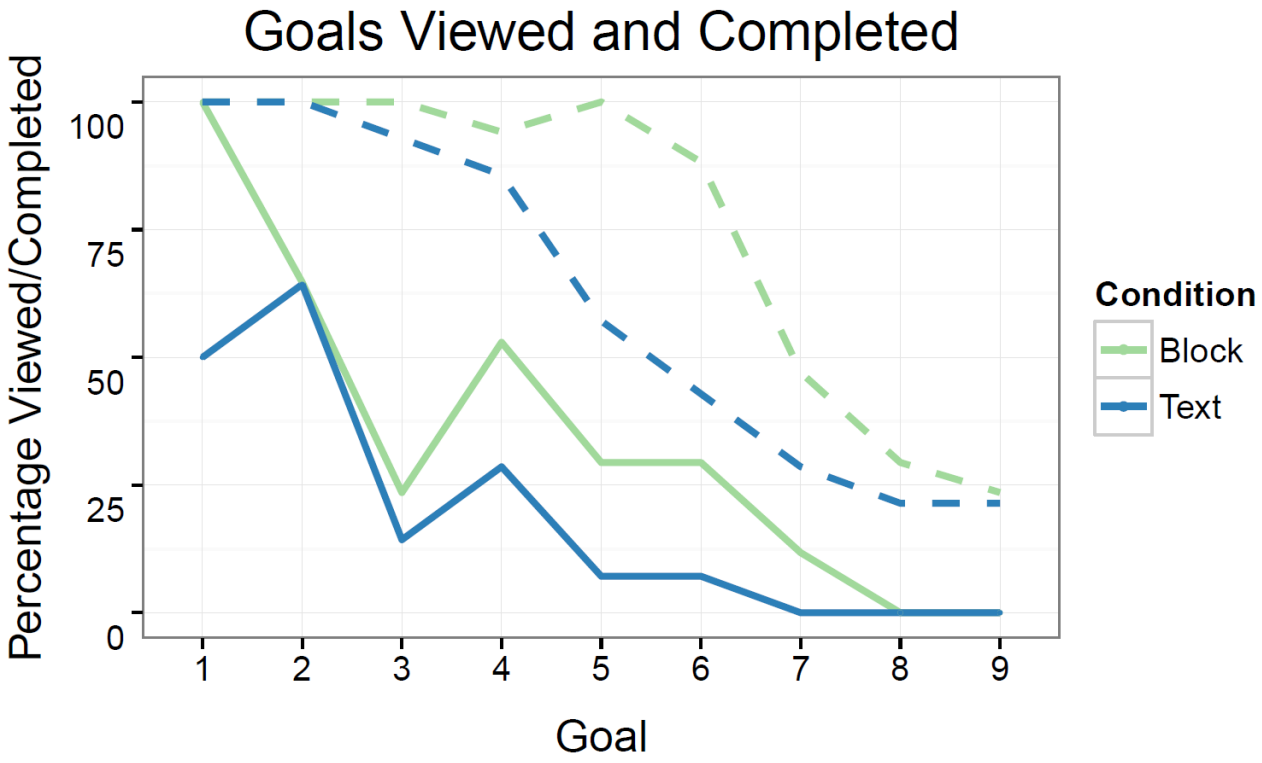
Performance - On-Task Behavior

- Total, Idle and on-task time were calculated
  - Idle means the student made no action for 60s
- Idle time was significantly less in the Block condition, and on-task time was significantly greater

Value	Block	Text	p	d
Total	2273.9 (596.4)	2208.0 (427.1)	0.851	–
Idle	407.2 (238.9)	793.5 (368.3)	0.002	1.27
Active	1866.8 (617.4)	1414.5 (463.1)	0.014	0.82

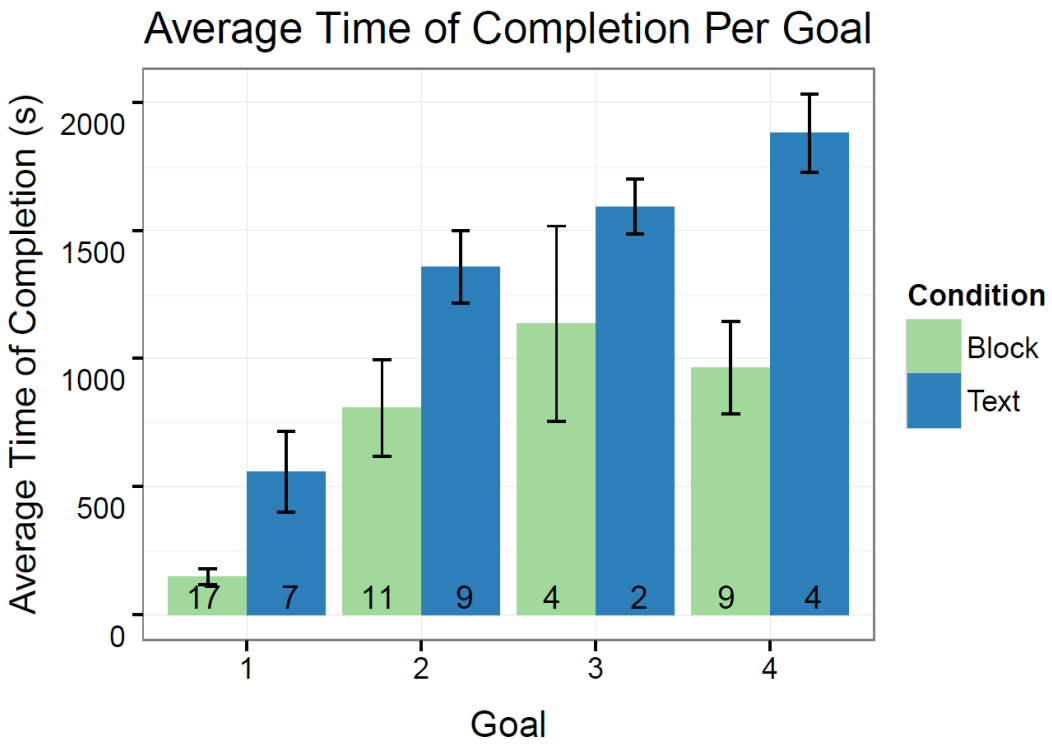
Performance - Achieving Goals

- A larger or equal percent of the Block condition completed each goal



Performance - Achieving Goals

- Students in the Block condition completed Goals 1, 2 and 4 after significantly less time had passed



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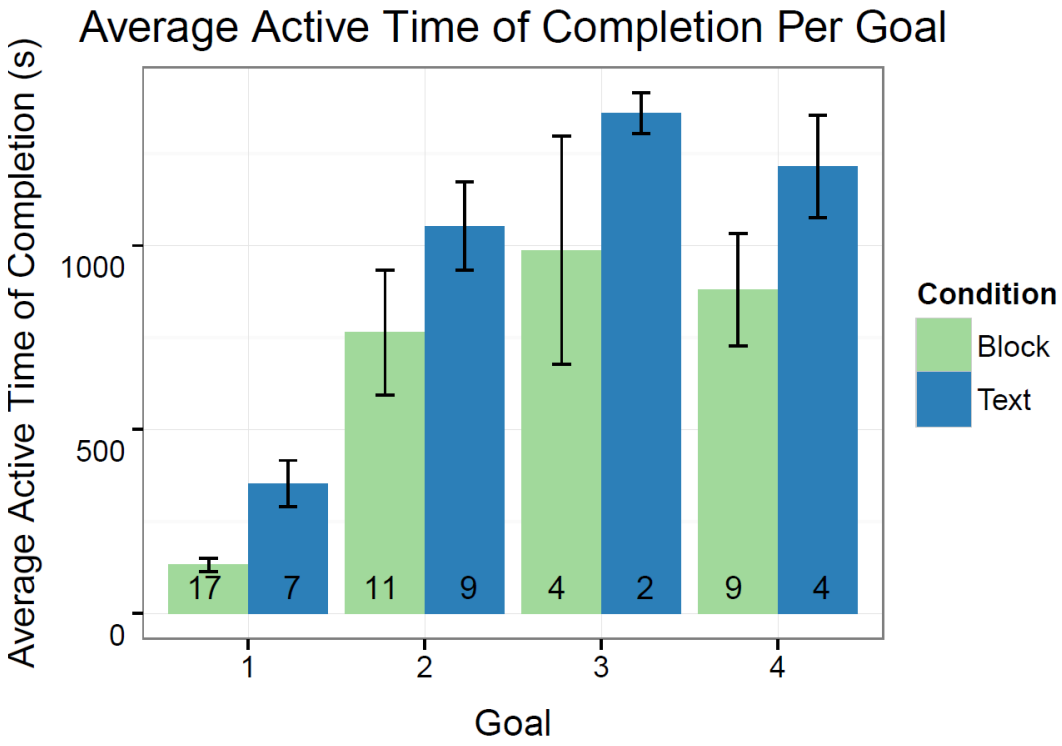

Discussion - RQ1

How did the interface affect users' attitudes towards computing?

- The activity did significantly improve students' perceived efficacy
  - This was not significantly different between groups
- No other attitudinal effects were observed in either condition
- We can offer no evidence to support the claim that the interface affects attitudes.
  - It is possible there was insufficient sample size after dropout to see an effect

Discussion - RQ2

How did the interface affect users' perceived difficulty of the activity?

- There were almost identical distributions of perceived difficulty
- This agrees with previous results (Lewis 2010)
- Perhaps this is because students proceed until they encounter something difficult
  - The block interface allows students to surpass the difficulties of syntax, and grapple with logic
  - This would suggest the categories of difficulty should still see different ratings

Discussion - RQ3

How did the interface affect users' performance on the activity?

- By almost any measure, the Block interface improved performance
  - Students spent more of their time on task
  - They completed more goals in less time

Limitations

- Results about a single Block-based programming environment may not generalize (McKay & Kölling 2013)
- The activity was designed for a block interface, which may have biased results
- The survey was not validated and had high dropout on the post-survey
- Populations were not identical
  - 6th vs 7th grade
  - Block group had higher initial interest scores

Future Work

- At what level of experience do the benefits of a block interface deteriorate?
- What mechanisms lead to increased, faster goal completion?
  - Is this simply a function of increased time on task?
  - Could it be an effect of biased program structure?
- With an improved survey and increased sample size, will we see an effect of the interface on student attitudes?
- (Stick around for some possible answers!)

Conclusions

- A block interface improves novice performance on an open-ended programming task
  - Faster completion of goals, and more goals completed
  - Less idle time and more time spent on-task
- We have no evidence to support a claim that the interface significantly affects novices attitudes towards computing or their perceived difficulty on the programming task

Questions?

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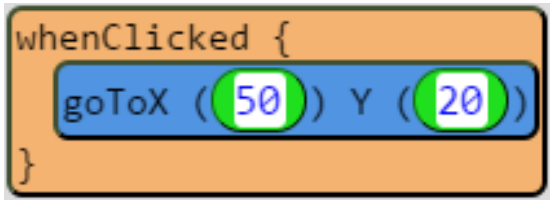
(Bonus Slides…)

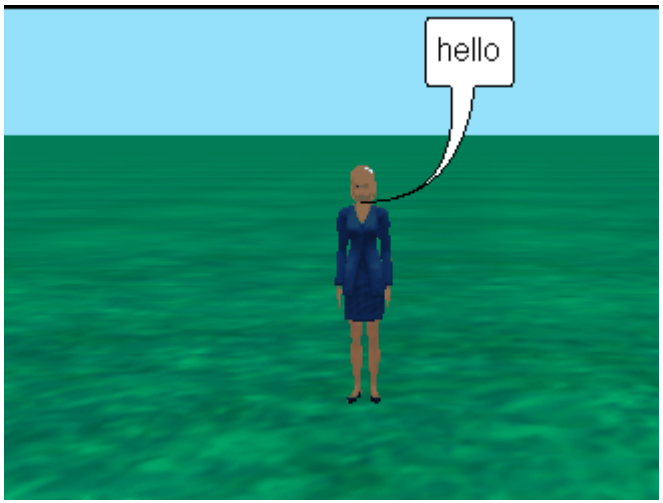
Block-Based Programming Environments

- Blocks can represent control structures, function calls, operators, expressions, etc.
- Blocks have slots which can have other nested blocks
- Generally, blocks are dragged-and-dropped
- For our purposes, they are procedural



Example - *Alice*

- One of the first drag-and-drop novice environments
  - Combines this with a menu interface
- Allows users to program objects in a 3D scene
- Object-oriented and event-driven paradigms
  - Users manipulate objects' properties and call their methods



Example - *Alice*

Evaluation:

- An Alice-based CS0 course, taken before or with a traditional CS1 course, significantly improves students' grades (Moskal et al. 2004)
  - These trends are more apparent in "high-risk" students, with no CS and less math experience
  - Also improves retention and attitudes
- Alice contextualizes Object-oriented programming and teaches good program design (Cooper et al. 2003)

Example - *Alice*

Evaluation:

- Modifying Alice with an increased emphasis on storytelling (e.g. easier animations) increased its appeal to girls (Kelleher et al. 2007)
  - Participants indicated increased interest in using Storytelling Alice and taking it home to use later

Novelty and Importance

- First study to *directly* compare block and textual programming interfaces
  - All other aspects of the environment are controlled
- Many resources go into the design of novice programming environments
  - It is important that we focus on the aspects that help students learn

Contributions

1. Strong evidence that a block interface has a positive impact on novice programmers
2. Support for previous findings that a block interface does not change perceived difficulty
3. A clear direction for future research into the mechanism by which block interfaces improve performance