Structured Editors

CS 695 / SWE 699: Programming Tools

Fall 2023

GEORGE MASON UNIVERSITY

Today

- Part 1 (Lecture)(~90 mins)

- 10 min break!

- Part 2 (Tech Talk)(20 mins)

- Part 3 (In-Class Activity)(40 mins)

Logistics

- HW1 due today
- HW 2 due in 2 weeks
- Anyone who has not yet signed up for a Tech Talk?

Overview

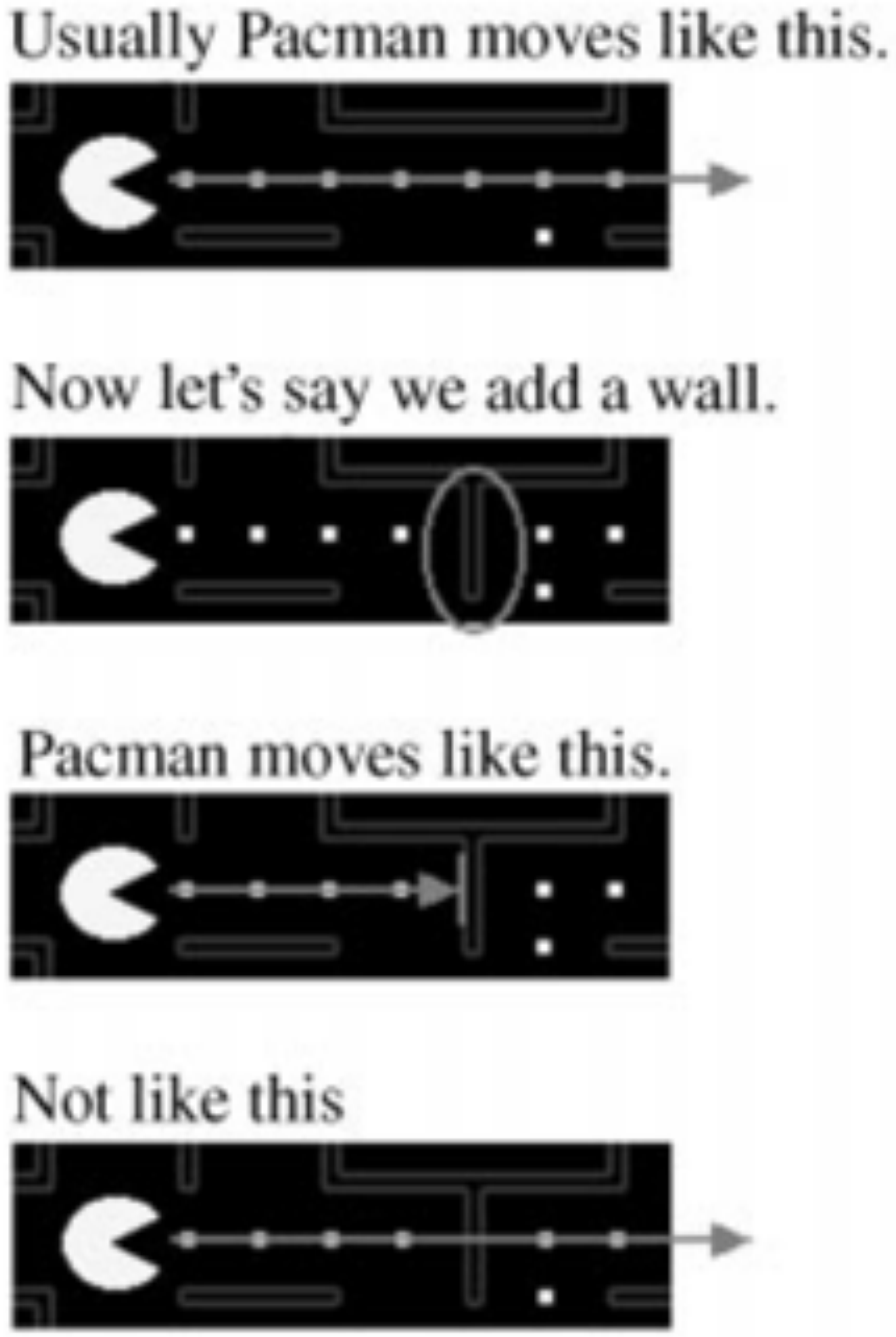
- Challenges in expressing and communicating computation
- Structured editors

What makes learning programming hard?

- What makes programming hard?
  - Is the challenge thinking computationally?
  - Or in understanding how to formally express computation in a programming language?

Slides partially adapted from Human Aspects of Software Development, Spring 2011, Lecture 11: How do people naturally think about computation? (Cyrus Omar)

Intuitions about programming language constructs



Do this: Write a statement that summarizes how I (as the computer) should move Pacman in relation to the presence or absence of other things.

- Twelve fifth graders in a Pittsburgh public elementary school
- Equally divided amongst boys and girls
- No prior experience programming
- *"The participants received no reward other than the opportunity to leave their normal classroom for half an hour and the opportunity to play a computer game for a few minutes."* ☺

[Pane et al., 2001]

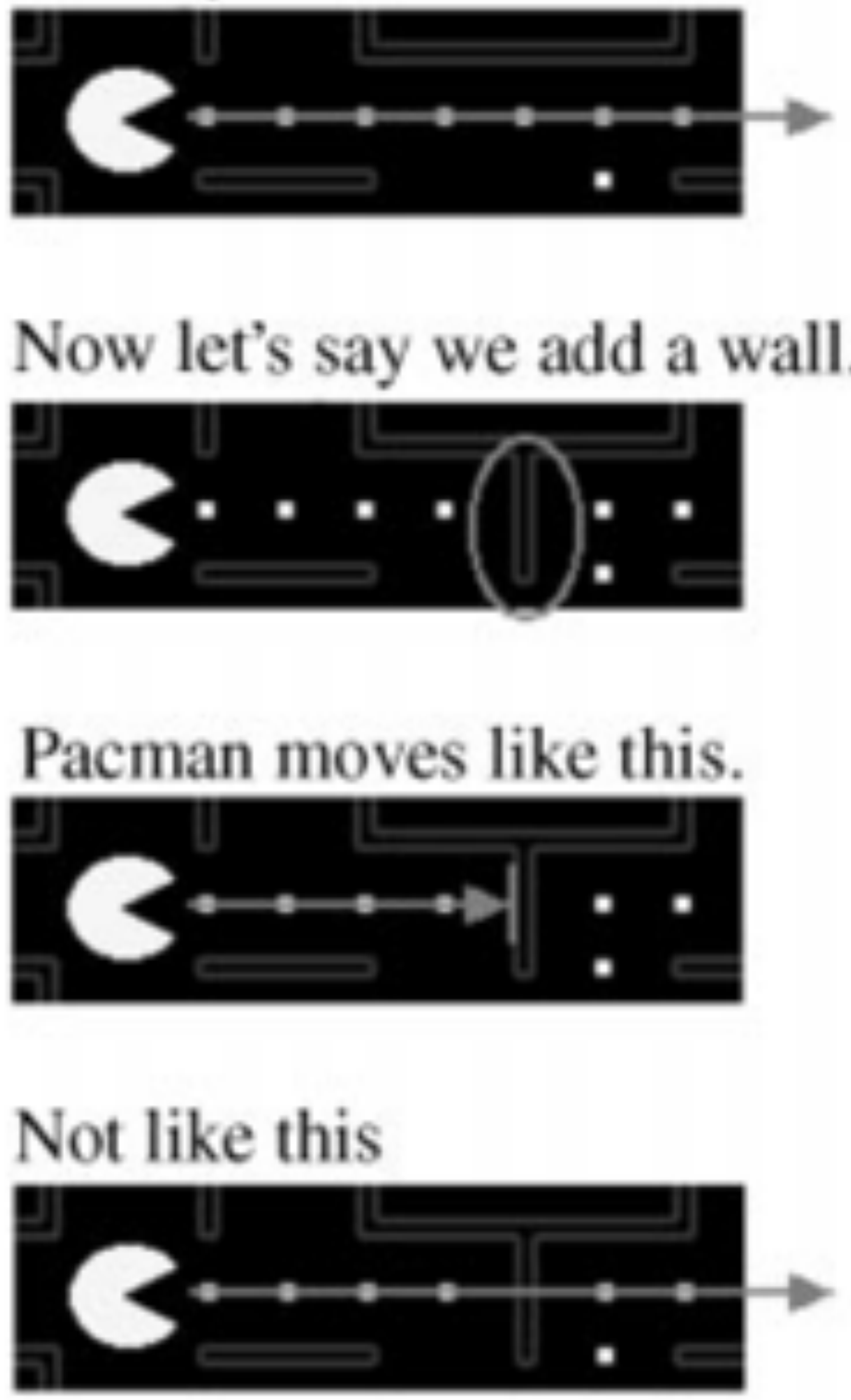
Intuitions about programming language constructs

Usually Pacman moves like this.

Now let's say we add a wall.

Pacman moves like this.

Not like this



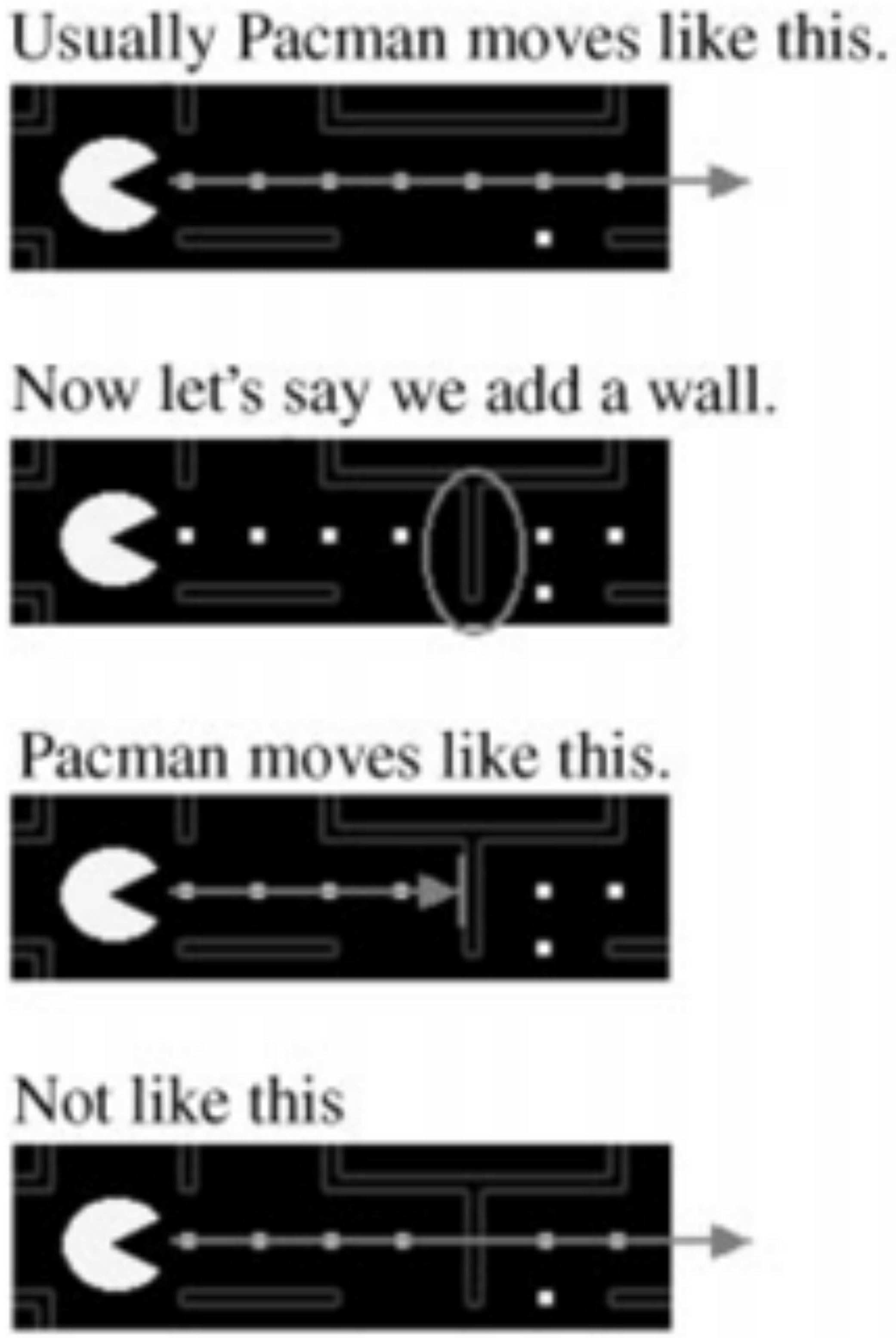
Do this: Write a statement that summarizes how I (as the computer) should move Pacman in relation to the presence or absence of other things.

Programming Style

- **54%** - production rules or event-based, beginning with *when*, *if* or *after*.
  - *When PacMan eats all the dots, he goes to the next level.*
- **18%** - global constraints
  - *PacMan cannot go through a wall*
- **16%** - declarations/other
  - *There are 4 monsters.*
- **12%** - imperative
  - *Play this sound. Display this string.*

[Pane et al., 2001]

Intuitions about programming language constructs



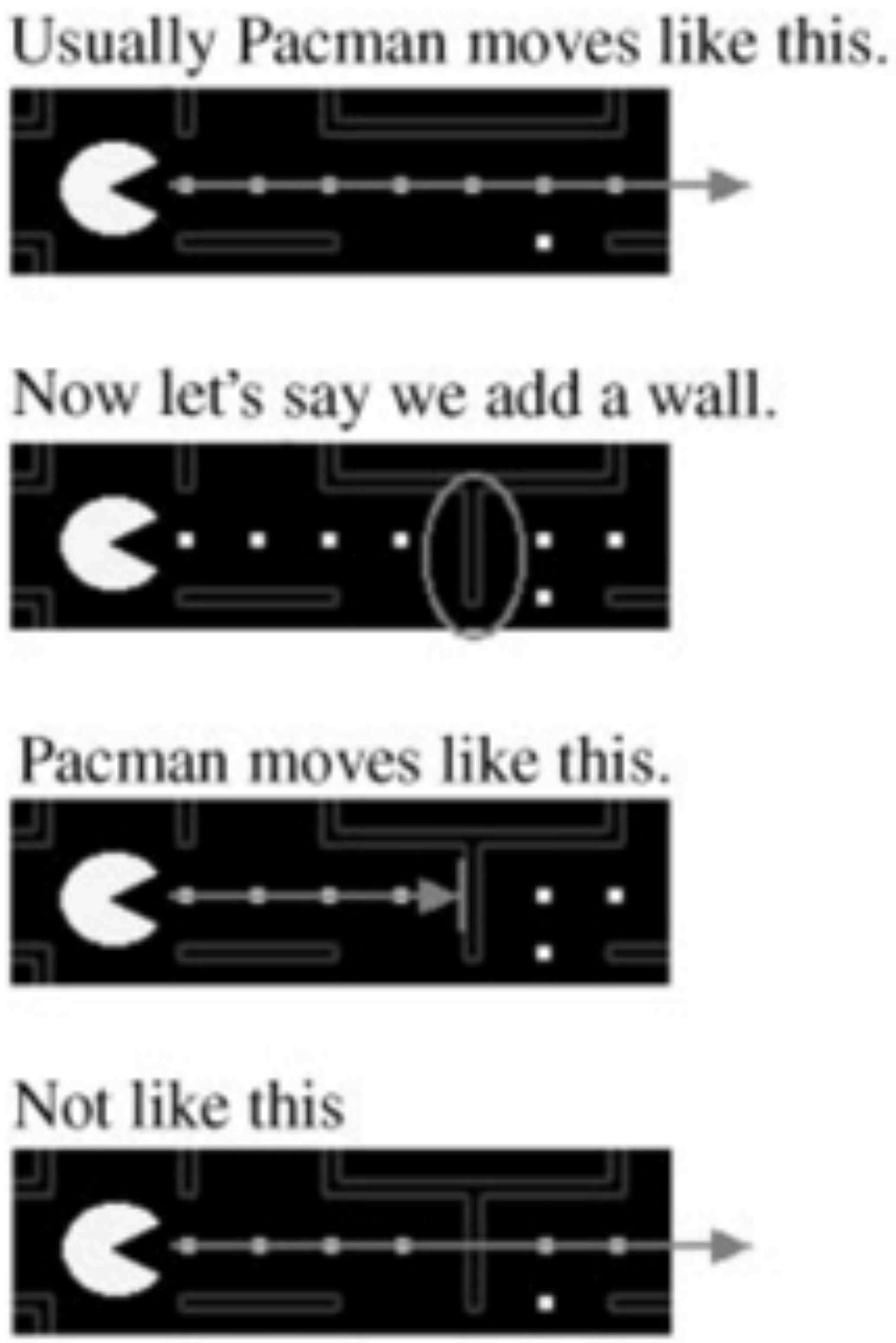
Do this: Write a statement that summarizes how I (as the computer) should move Pacman in relation to the presence or absence of other things.

Modifying State

- **61%** - behaviors were built into the entity, e.g. OO
  - *Get the big dot and the ghost will turn colors…*
- **20%** - direct modification of properties
  - *After eating a large dot, change the ghosts from original color to blue.*
- **18%** - other

[Pane et al., 2001]

Intuitions about programming language constructs



Do this: Write a statement that summarizes how I (as the computer) should move Pacman in relation to the presence or absence of other things.

OR

- **63%** - boolean disjunction
  - *To make PacMan go up or down, you push the up or down arrow key*
- **20%** - clarifying or restating the prior item
  - *When PacMan hits a ghost or a monster, he loses his life.*
- **18%** - meaning *otherwise*
- **5%** - other

[Pane et al., 2001]

Intuitions about programming language constructs

No.	First name	Last name	Average score	Performance
1	Sandra	Bullock	3000	
2	Bill	Clinton	60 000	
3	Cindy	Crawford	500	
4	Tom	Cruise	5000	
5	Bill	Gates	6000	
6	Whitney	Houston	4000	
7	Michael	Jordan	20 000	
8	Jay	Leno	50 000	
9	David	Lettermen	700	
10	Will	Smith	9000	

Question 5A
- Describe in detail what the computer should do to obtain these results.

No.	First name	Last name	Average score	Performance
1	Sandra	Bullock	3000	Fine
2	Bill	Clinton	60 000	Extraordinary
3	Cindy	Crawford	500	Poor
4	Tom	Cruise	5000	Fine
5	Bill	Gates	6000	Fine
6	Whitney	Houston	4000	Fine
7	Michael	Jordan	20 000	Extraordinary
8	Jay	Leno	50 000	Extraordinary
9	David	Lettermen	700	Poor
10	Will	Smith	9000	Poor

FIGURE 3. Depiction of a problem scenario in study two.

Insertion into a data structure

- **75%** - no mention of making room for new element
  - *Put Elton John in the records in alphabetical order*
- **16%** - make room for element before inserting it
  - *Use the cursor and push it down a little and then type Elton John in the free space*
- **6%** - make room for element after inserting it
- **4%** - other

[Pane et al., 2001]

Is natural language programming a solution?

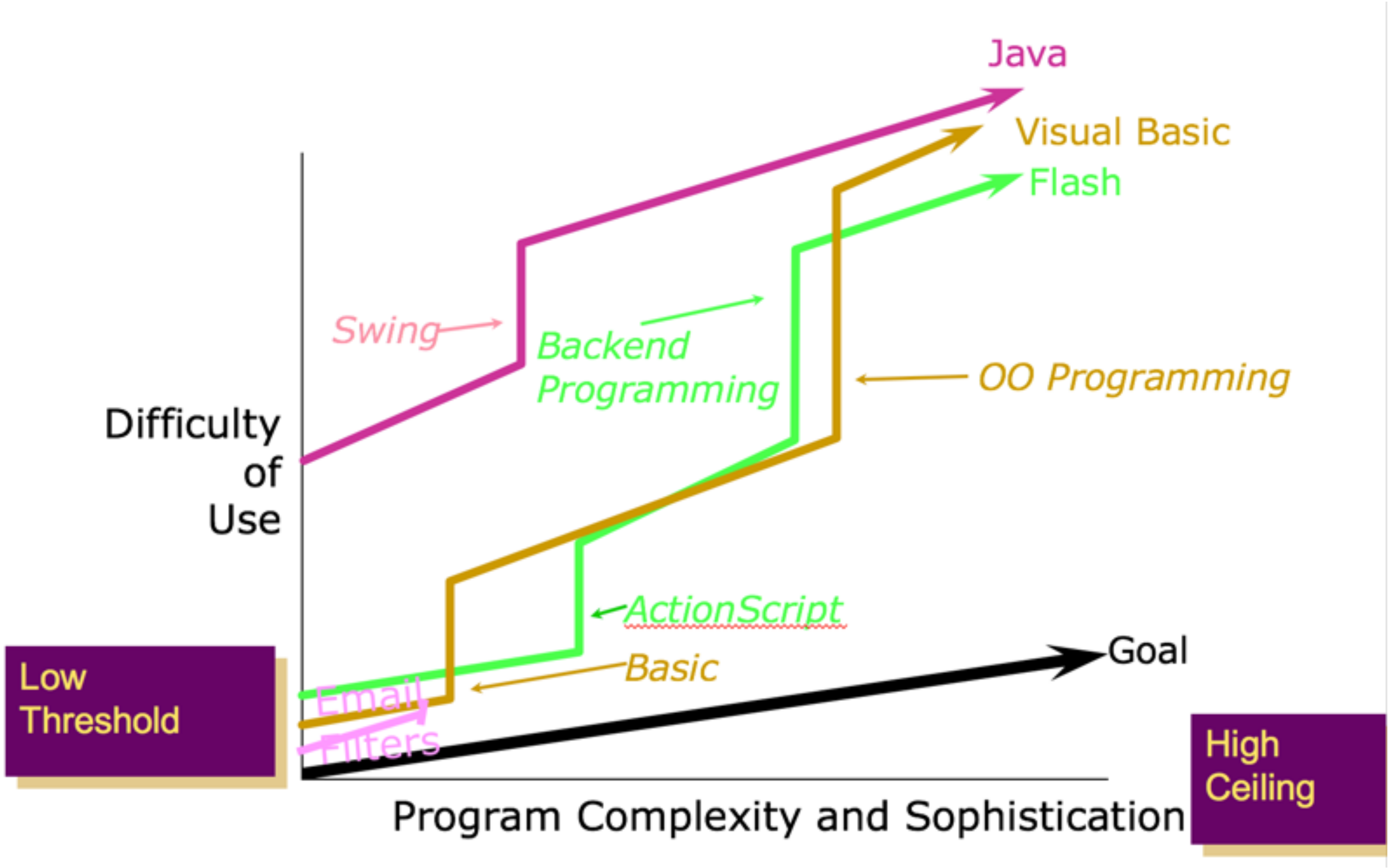
A **difficult proposition** – natural language is complex and imprecise

- Computer and programmer do not have a shared context [Nardi, 1993]; programmers cannot use rules of cooperative conversation [Grice, 1975]
- Not obvious where the computer's limits are

Novices **can use formal languages** if designed carefully [Bruckman and Edwards, 1999]

- Describing the instructee as a naïve alien increases precision of instructions [Galotti, 1985]
- Anthropomorphizing computers is counterproductive [du Boulay, 1989]

Goal: Gentle Slope Systems



Myers, B.A., Smith, D.C., and Horn, B. “Report of the `End-User Programming' Working Group,” in *Languages for Developing User Interfaces. 1992. Boston, MA: Jones and Bartlett. pp. 343-366.*

Minimalist Learning Theory

- *Choose an action-oriented approach*
  - Provide an **immediate** opportunity to act, encourage self-directed exploration & innovation, prioritize **user's** goals over delivery of information
- *Anchor the learning tool in the task domain*
  - Use **real** tasks as instruction, organize instruction around task steps
- *Support error recognition & recovery*
  - Prevent mistakes when possible, provide error information that offers not only detection but 'on-the-spot' diagnosis & recovery
- *Support reading to do, study, locate*
  - Make instructions brief & self-contained to support different levels of engagement

Carroll, J. (1990) The Nurnberg Funnel: Designing Minimalist Instruction for Practical Computer Skill. MIT Press, Cambridge, MA.

Problem frames

- Developers approaching messy problem interpret it with a *frame*
- Imposes boundaries on what learners will consider

Simplify typing code

- If key barrier is syntax, reduce challenge of working with syntax
  - Reduce constructs in programming language
  - Simplify constructs in programming language
  - Eliminate possibility of syntax errors

Beginners All-Purpose Symbolic Instruction Code (BASIC, 1963)

- Support a subset of instructions & remove unnecessary syntax
- Offer rapid feedback through interpreted language
- Offer simplified statements w/ 3 parts: line number, operator, operands

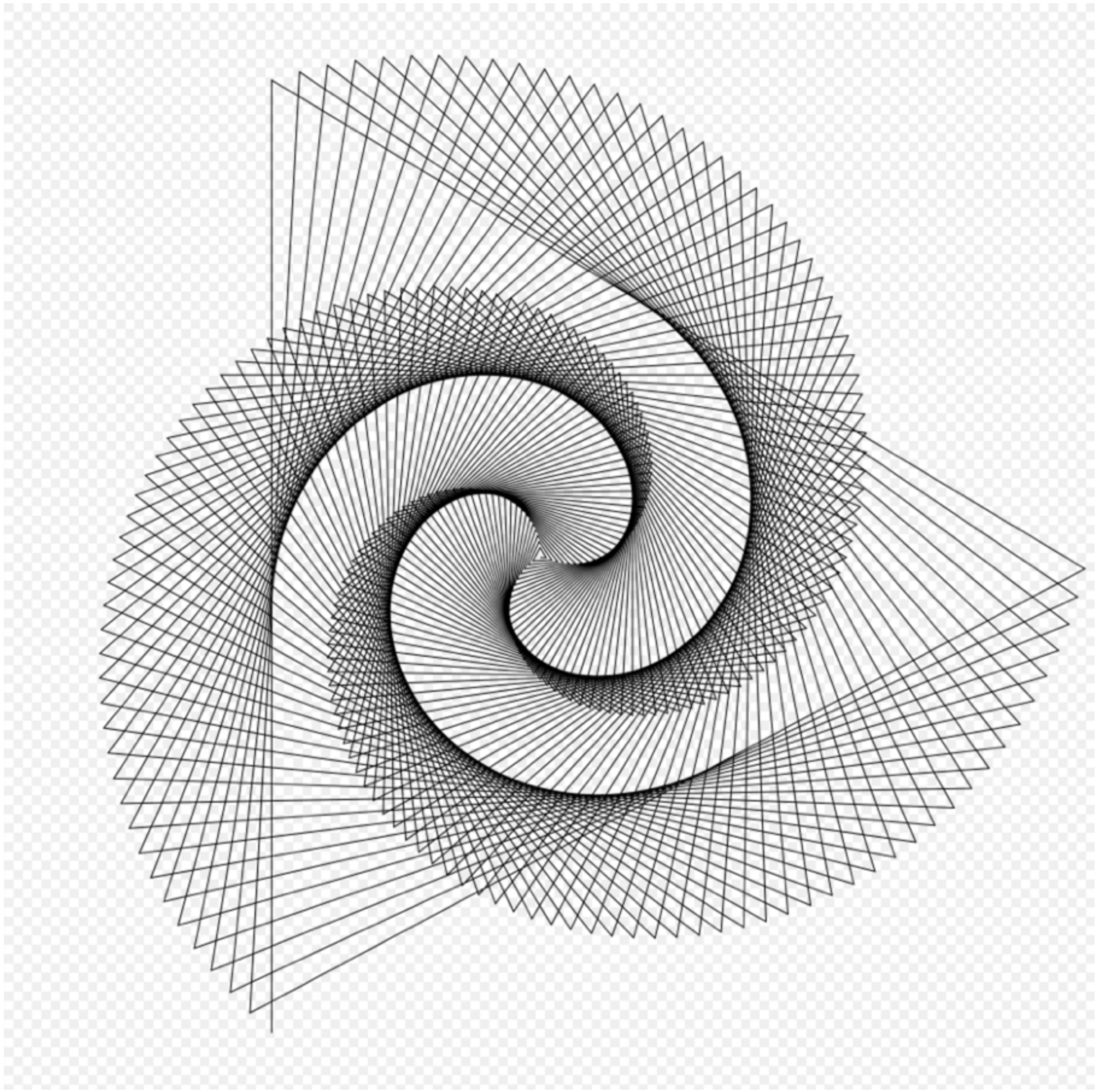
FORTRAN:	BASIC:
do 30 i = 1, 10 m = m + I 30 continue	100 FOR I = 1 TO 10 110 LET S = S + I 120 NEXT I

Figure 2. A *for* loop to compute the sum of the numbers from 1 to 10 written in FORTRAN and BASIC.

J.G. Kemeny and T. Kurtz, Dartmouth College, 1963

LOGO (1967)

- Supports manipulating turtle to draw pictures
  - Move forward 10 spaces
  - Turn left 90 degrees
- Offers dialect of LISP with less punctuation
- Supports creating music, translating languages, and much more



By 414owen - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=51472272

Seymour Papert, MIT, 1967

Interacting with objects

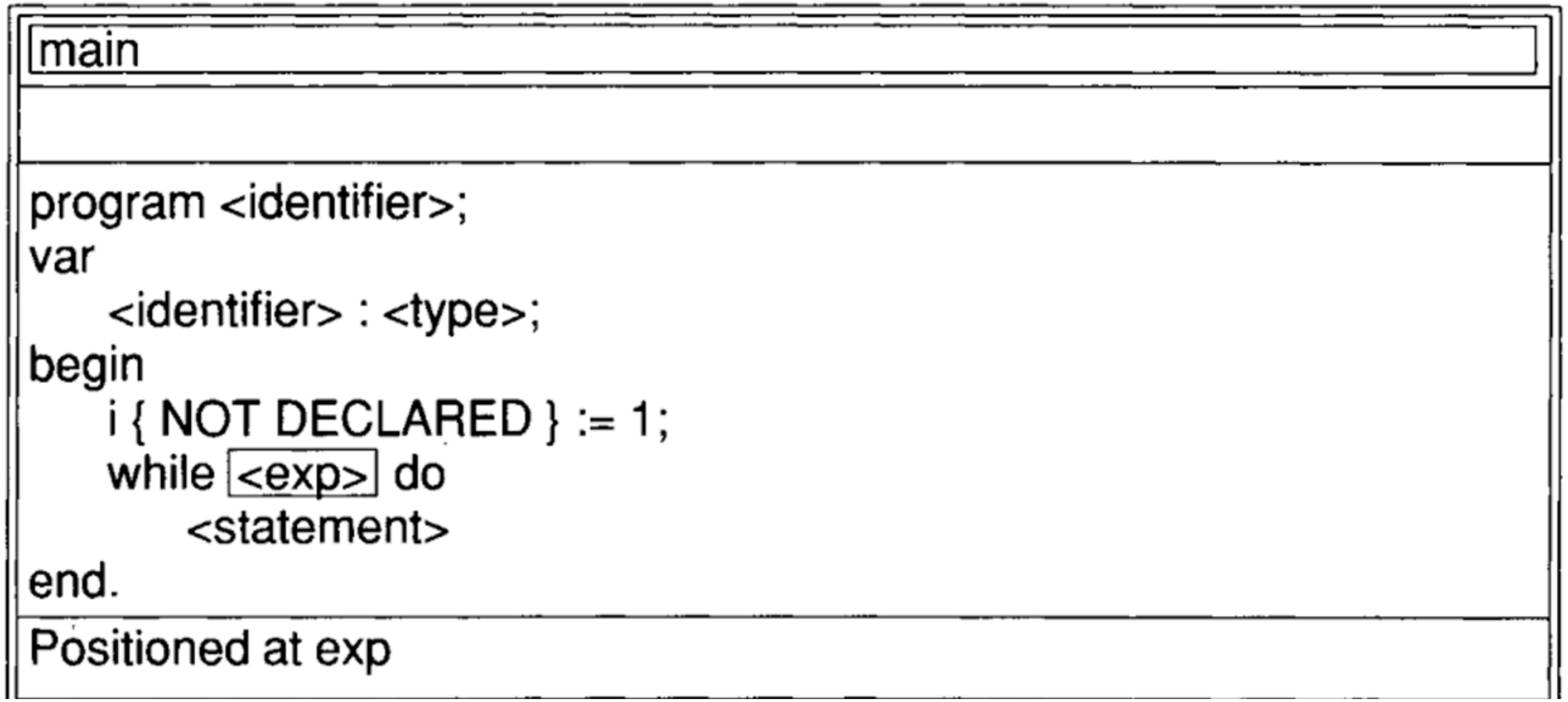
Figure 4. A view of the My Magic Castle courtyard. The user is creating the rule "Nicky should dance when it meets the horse."

- Enable users to create objects & rules on how objects behave

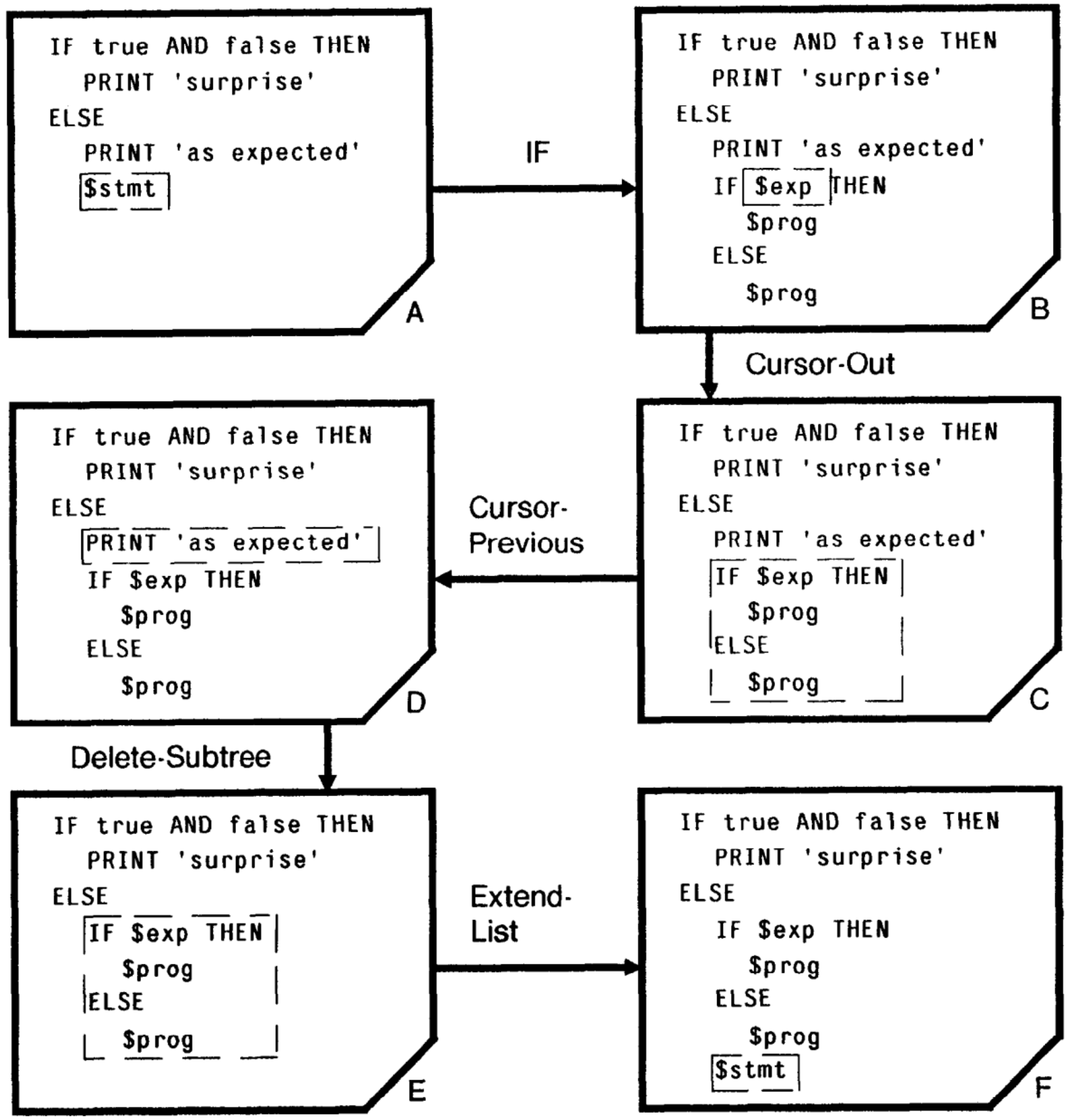
My Make Believe Castle: Logo Computer Systems Incorporated, 1995 [LCSI, 1995]

Structured editors

Cornell Program Synthesizer/
Synthesizer Generator 1981



ALOE



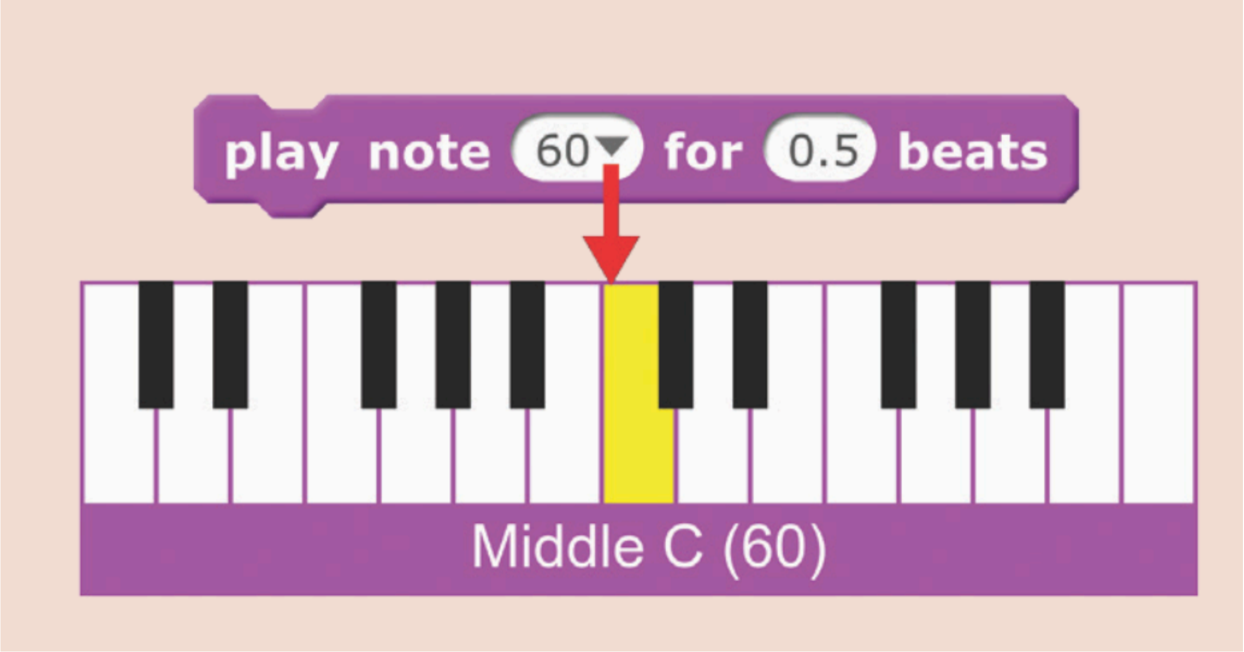
The cursor, representing the current node of the tree, is displayed in dashed boxes. Unfilled-in nodes, called *meta-nodes*, are displayed as $CLASS where CLASS defines the language constructs that may replace the node.

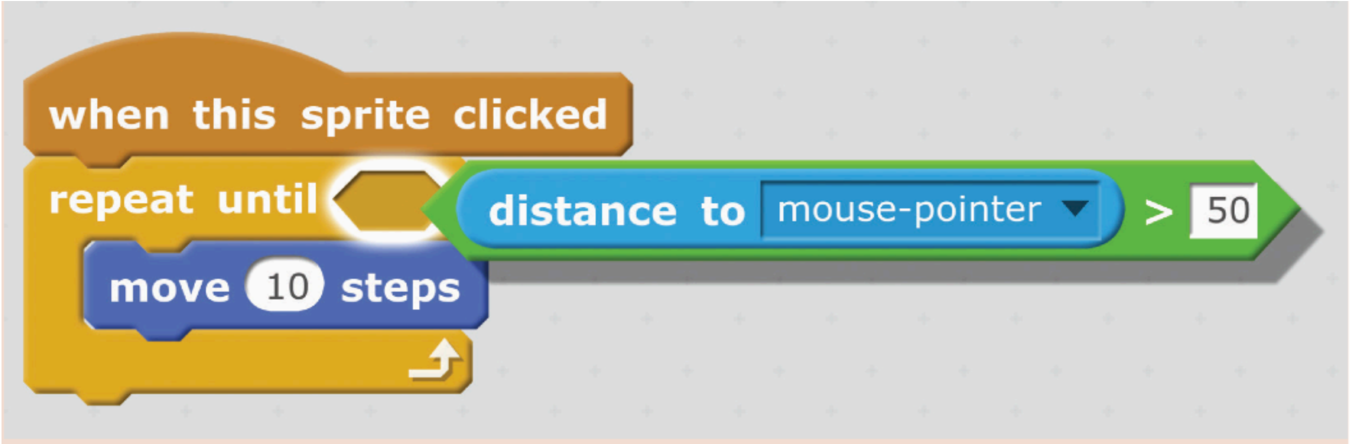
Screen A shows an existing program. In screen B, an IF node replaces $stmt as the cursor moves to the first new meta-node. Applying **cursor-out** increases the focus of attention as shown in screen C. In screen D the cursor moves to the previous statement in the list. Deleting the PRINT statement yields screen E. Screen F shows the state after the list of statements is extended.

Figure 2-4: Sample ALOE Session

- Initially programmers conceive of a program as structure; then they transform their mental picture of structure into text; and finally a parser transforms the text back into structure. WC believe that the user benefits greatly when they arc relieved from the first transformation of structure in to text. This has the added benefit of allowing us to eliminate, either totally or partially, the need for parsing as the user develops ALOE trees directly.
- Our editors further provide a good mechanism for replacing the traditional {edit, compile, link, debug) cycle with a more natural {edit, execute) cycle; indeed, the LOIW system just described is based on this simple tools cycle. We believe that this is just one example of situations where traditional mechanisms cm be replaced by mechanisms that arc more suitable to users.

Scratch 2005

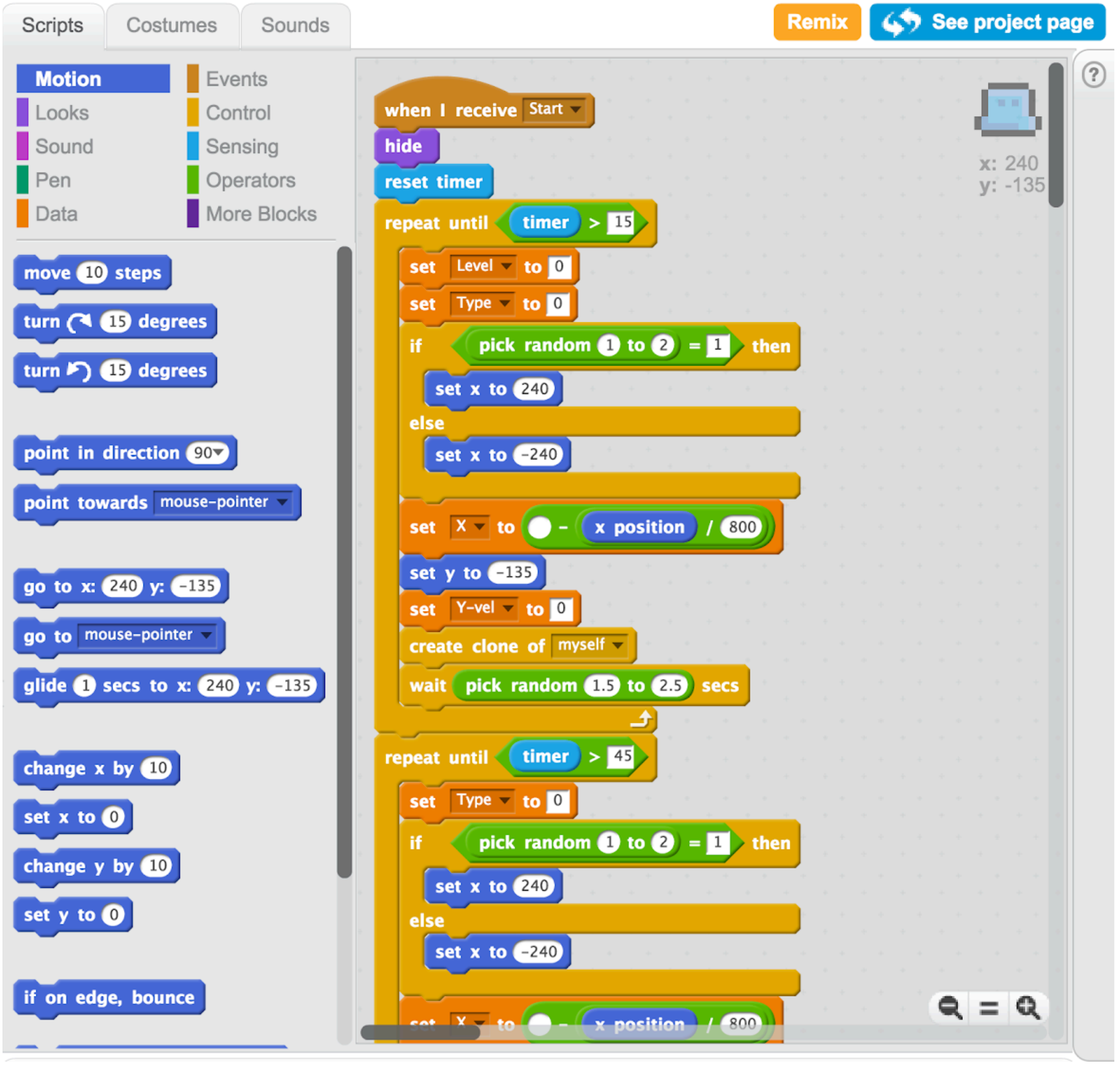




Challenges addressed by blocks based editors

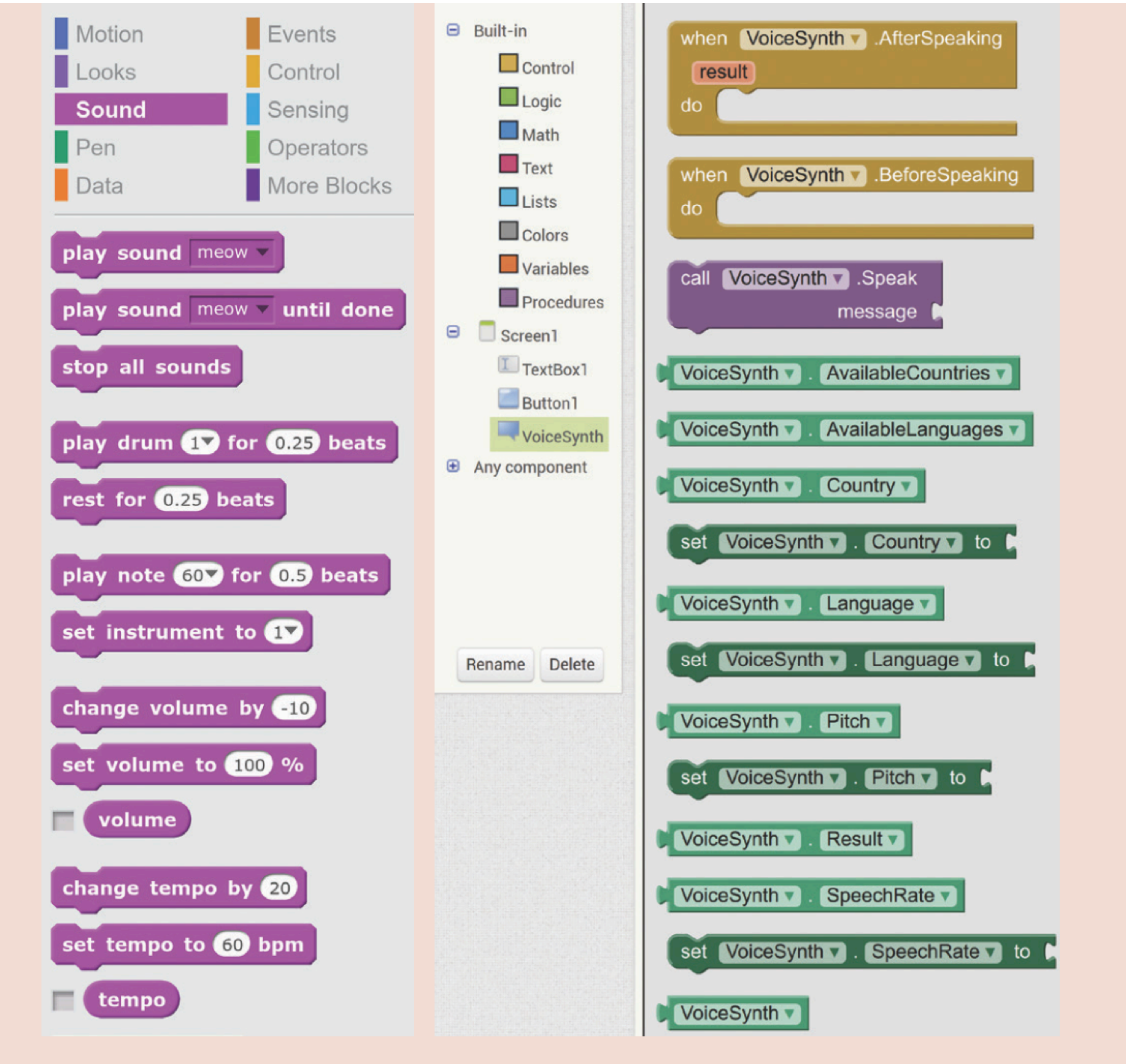
Learning programming vocabulary

- How to express computation in code?
- Learning 100-200 new words and understanding concepts behind them is overwhelming
- Much easier to select options from a palette
- Recognition easier than recall



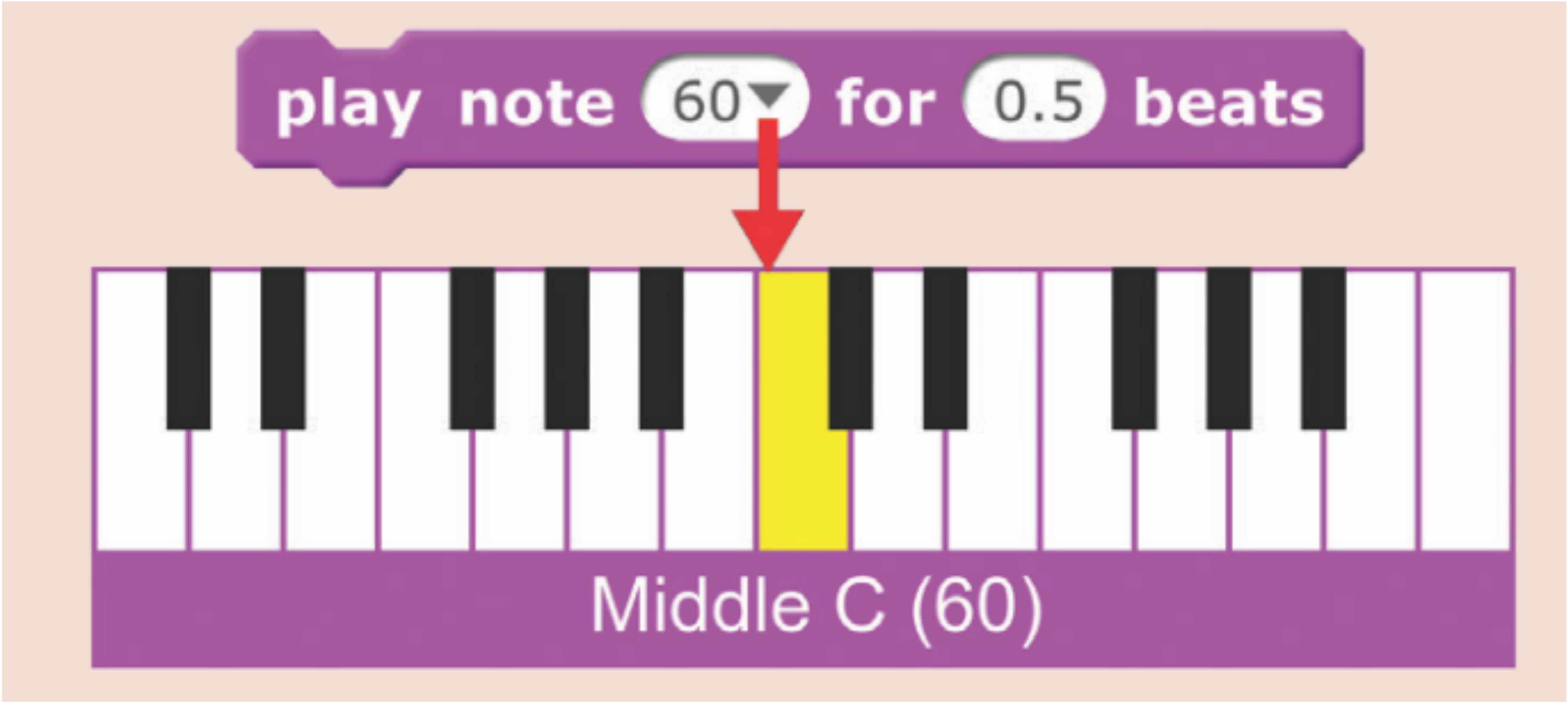
Palettes vs. Autocomplete

- Both make it easier to find a command
- But autocomplete
  - Requires user to already remember part of what they're looking for
  - Lacks hierarchic organization of similar functions



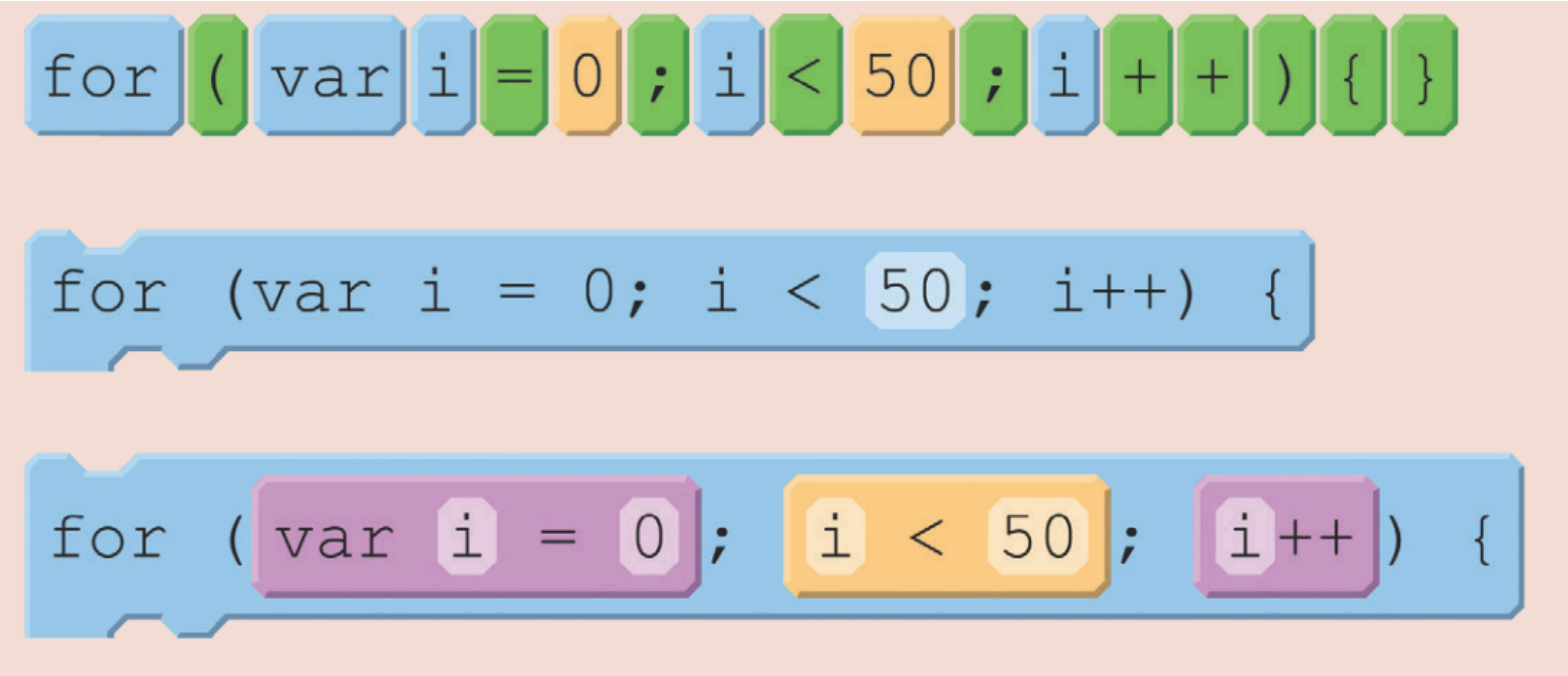
Filling in arguments

- Remembering order, type, and valid argument values is hard
- Block languages have
  - automatically generated holes showing what arguments are expected
  - useful default operands
  - drop down menus and specialized editors to create and change operands
  - extra text explaining operand meaning



Reading syntax

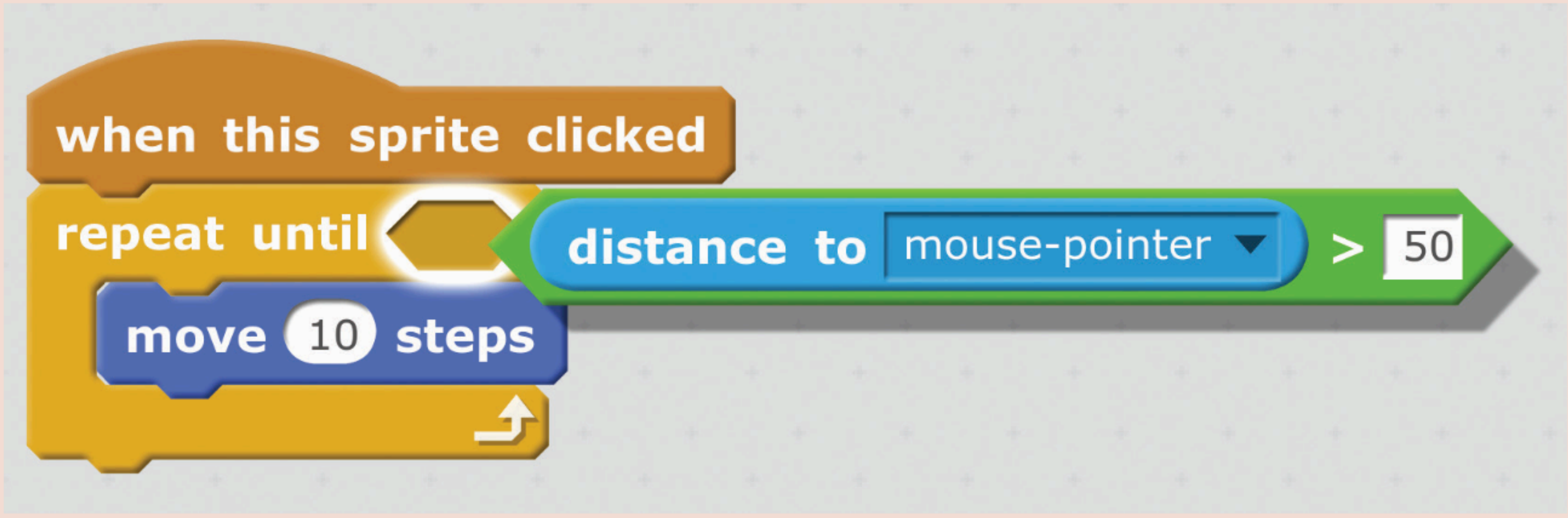
- Textual languages have lots of syntax that is unclear to newcomers
- Showing the structure of the code makes visible the chunks that experts eventually use to understand code



Following syntax

- Developers, particularly novices, make syntax errors all the time
  - Might be slip - intended to do something else
  - Or mistake - didn't know the right way to do it
- Structured editors make syntax error impossible
  - Each type has a distinct shape
  - Commands connect vertically with nubs and notches
  - Expressions are smooth

Figure 5. Block shapes show and enforce rules composition. Scratch commands compose vertically, and expressions fit into holes. Here, a Boolean expression (diamond shape) is being dropped into a matching hole for a loop test condition.



Tinkering

- In textual languages, hard to know what the output of an expression is
- In blocks languages with liveness, can execute fragments just by clicking on them
- (More on live programming later)

Intuitive words and concepts

- Textual languages rely on keywords that are incomprehensible to novices
  - e.g., for, !=
- Blocks based languages choose keywords that better leverage real world concepts and ideas
  - e.g., repeat, unequal

Example reuse

- Professional reuse code all the time, but adapting can be hard
- Blocks based languages can support this process, finding dependencies required to make a line of code run

Limitations of blocks based editors

Higher viscosity for small edits

- Writing (a/2 + b/2) requires a number of steps to find and drag blocks for 3 arithmetic operators and fill in with variables and numbers
  - Faster, for an experienced programmer, with a textual language
- Rearranging expression from (a/2 + b/2) to (a+b)/2 requires more steps to change the structure than similar textual structure

Other disadvantages

- Low density - blocks take up more space
- Search - hard to find code
- Source control - may not work without textual representation

Hybrid editors

- Can combine textual and blocks based editors
  - Text-style entry of blocks - enter blocks as text, choosing blocks through autocomplete
    - Can do drag and drop for bigger structure, and text for smaller
  - Bidirectional mode switching
    - Switch between blocks and text, edit in either

Figure 6. Greenfoot's Stride editor combines text-style editing for expression-level details with drag-and-drop blocks for higher-level program structure.

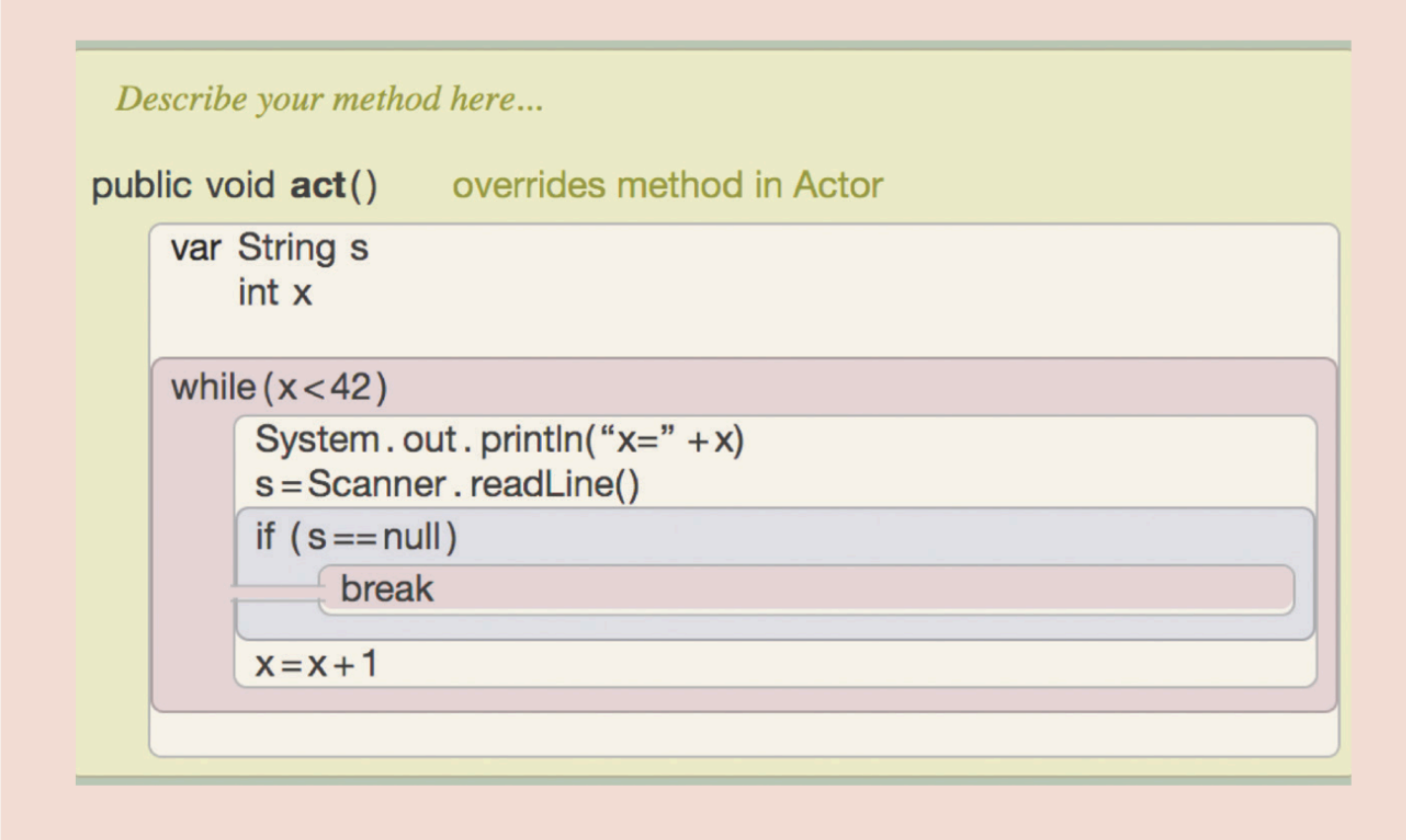
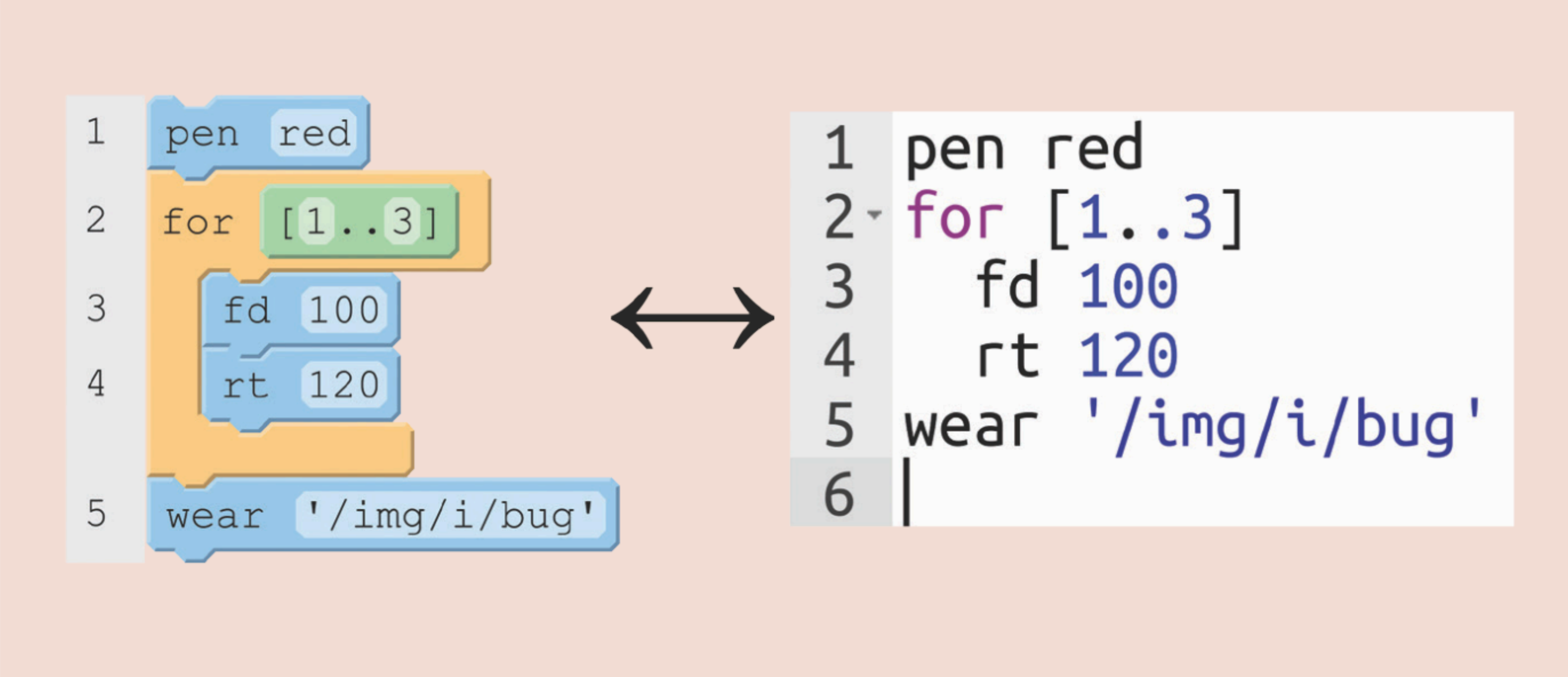


Figure 7. Pencil Code provides bidirectional switching between blocks and text. Mode switching allows users to learn with blocks and edit quickly with text.



Examples

Many domains use blocks programming

Figure 8. Blocks programming in MadeUp. 3D printing is an area of rapid innovation, and blocks make it possible to use new 3D modeling languages without a steep learning curve.

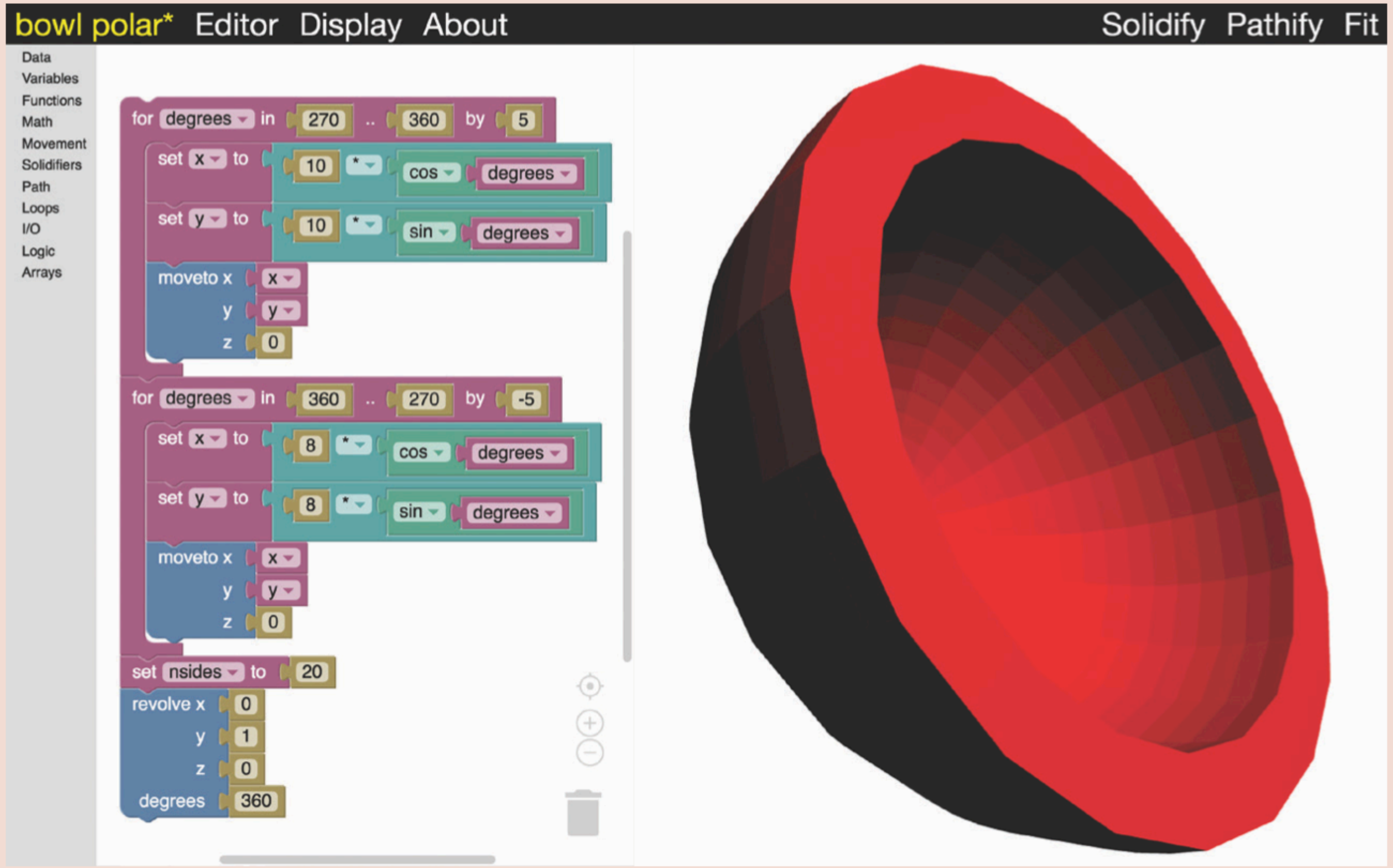
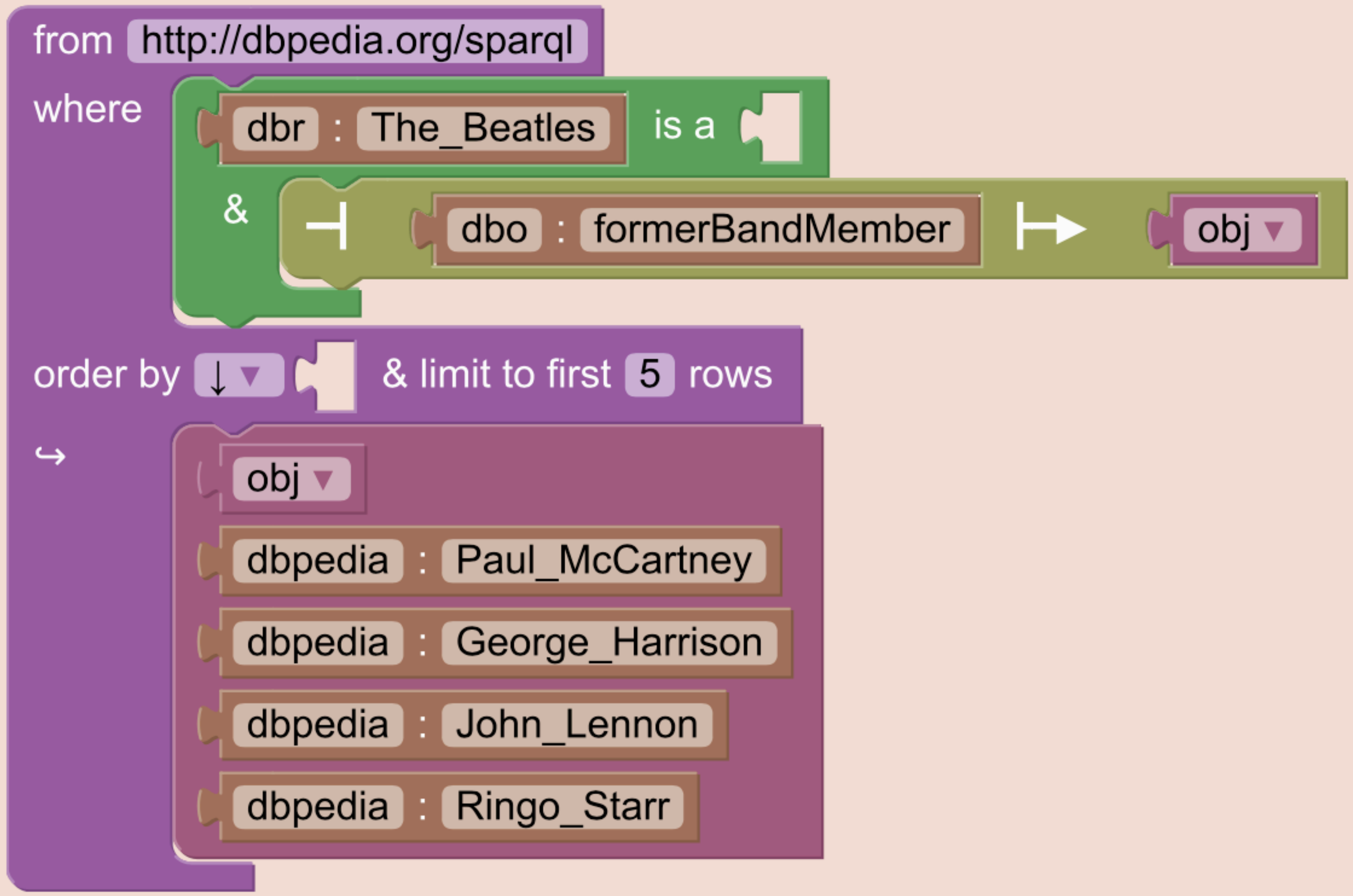
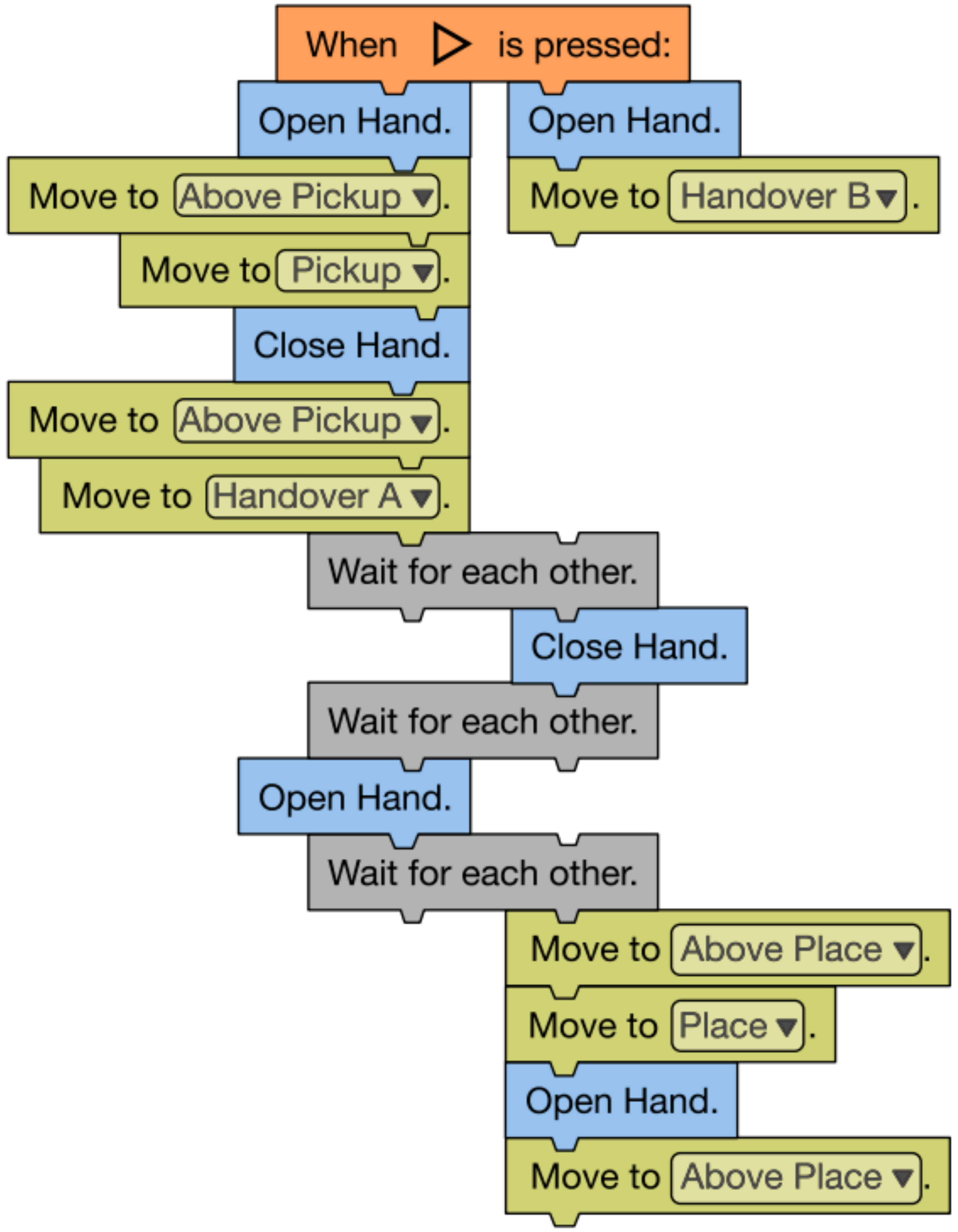


Figure 9. The SPARQL playground is a blocks-based query execution tool that provides blocks for constructing queries of RDF data. Query results (bottom) are also provided as blocks, and they can be dragged to build into other queries.



Robot automation




Microsoft
Menu
A
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MICROSOFT RESEARCH WEBINAR

Thomas Ball and Stefania Druga

From player to creator: Designing video games on gaming handhelds with Microsoft TileCode

Now on demand

https://vimeo.com/228372549/140738254

10 min break

Tech Talk: Scratch

In-Class Activity

- In groups of 2, build pong in Scratch

- https://scratch.mit.edu/projects/editor/?tutorial=getStarted