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Department of Computer Science

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Programming by Voice: A Hands-Free Approach for Motorically Challenged Children

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Committee:
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Dr. Sandra Nichols
Dr. Randy Smith
Dr. Susan Vrbsky

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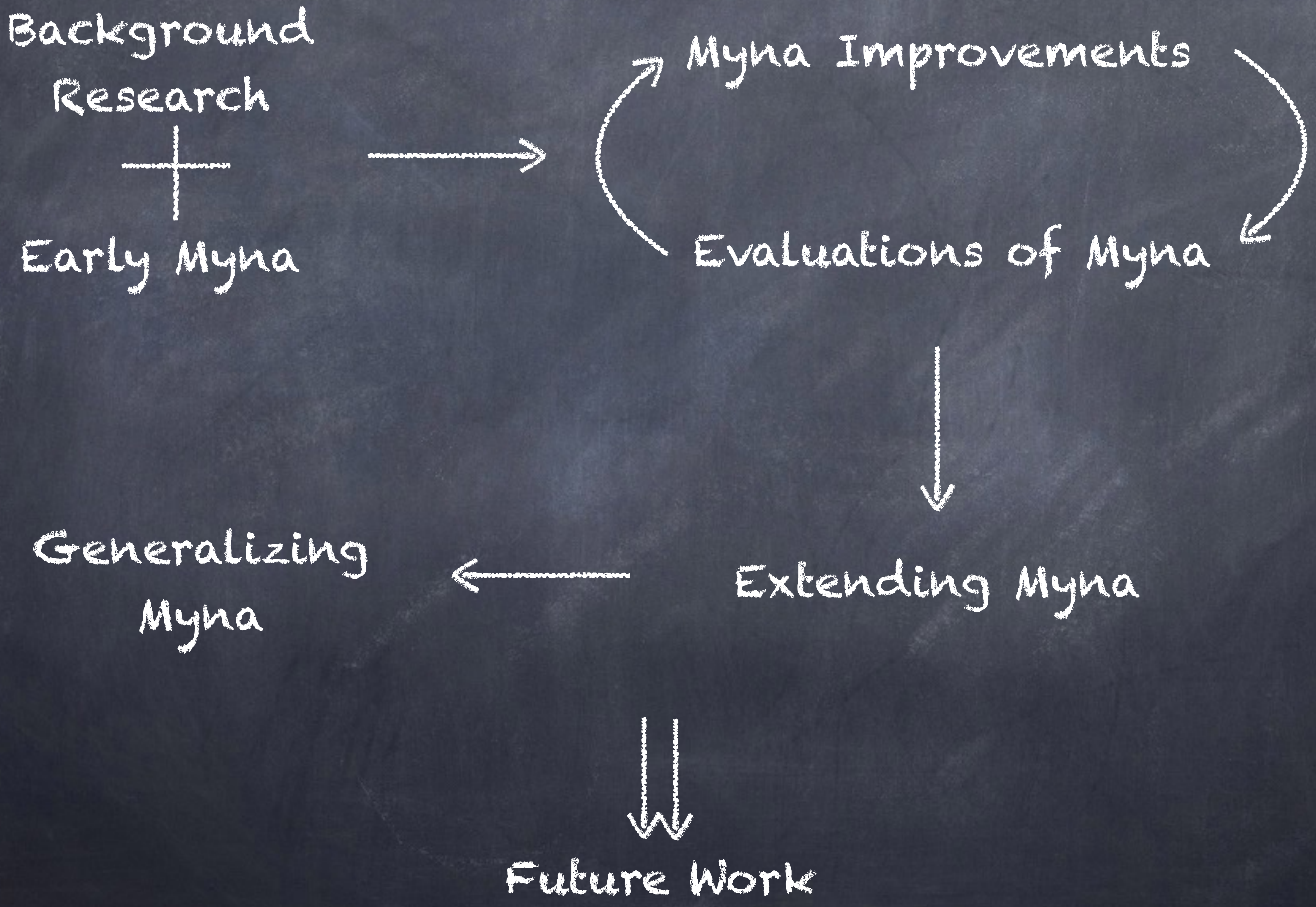
> Unless someone like you cares a whole awful lot, Nothing is going to get better. It's not.

- The Lorax, Dr. Seuss

Dissertation Roadmap



Background Research + Early Myna

Myna Improvements

Evaluations of Myna

Extending Myna

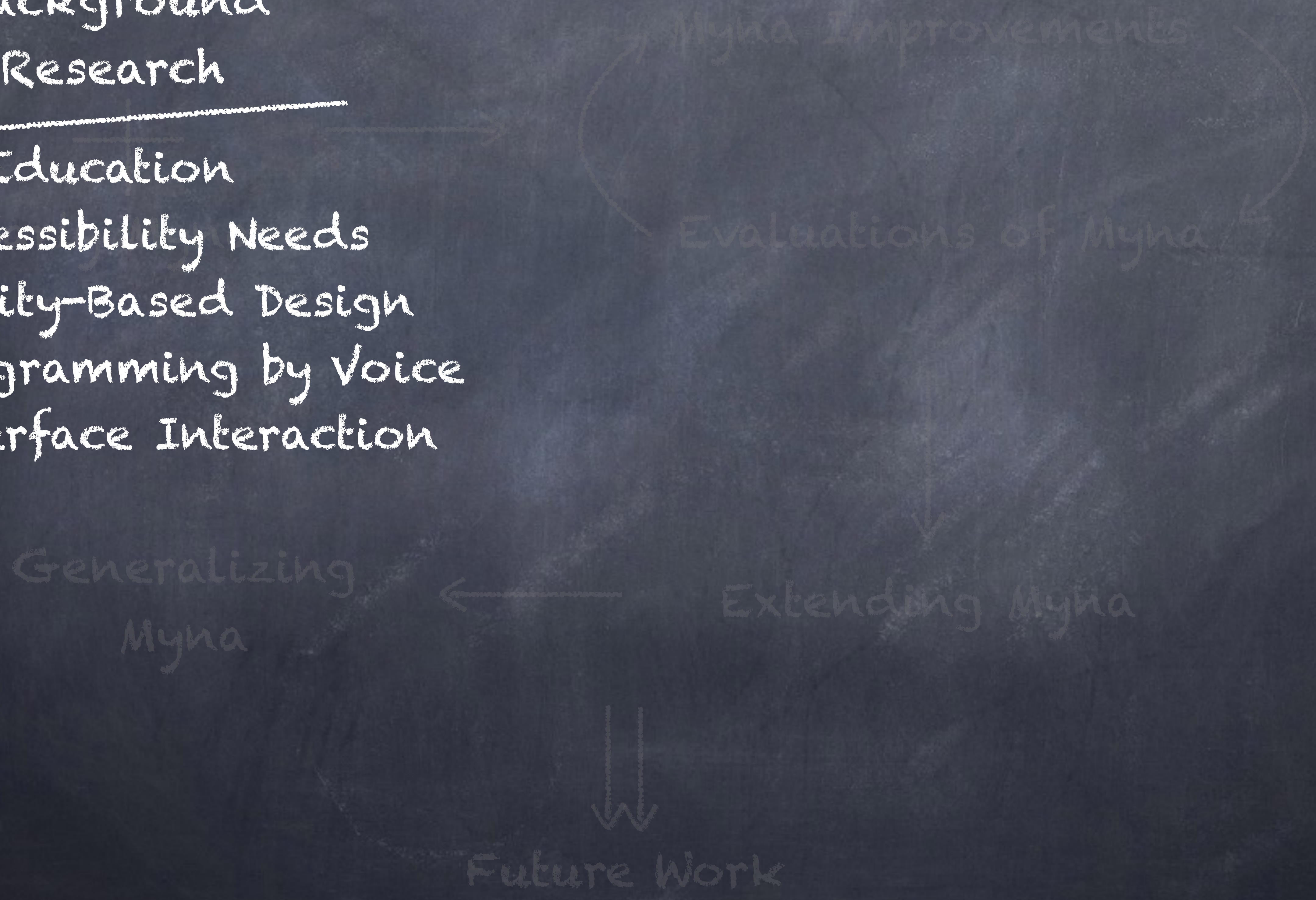
Generalizing Myna

Future Work

Dissertation Roadmap

Background Research

- CS Education
- Accessibility Needs
- Ability-Based Design
- Programming by Voice
- Interface Interaction



Myna Improvements

Evaluations of Myna

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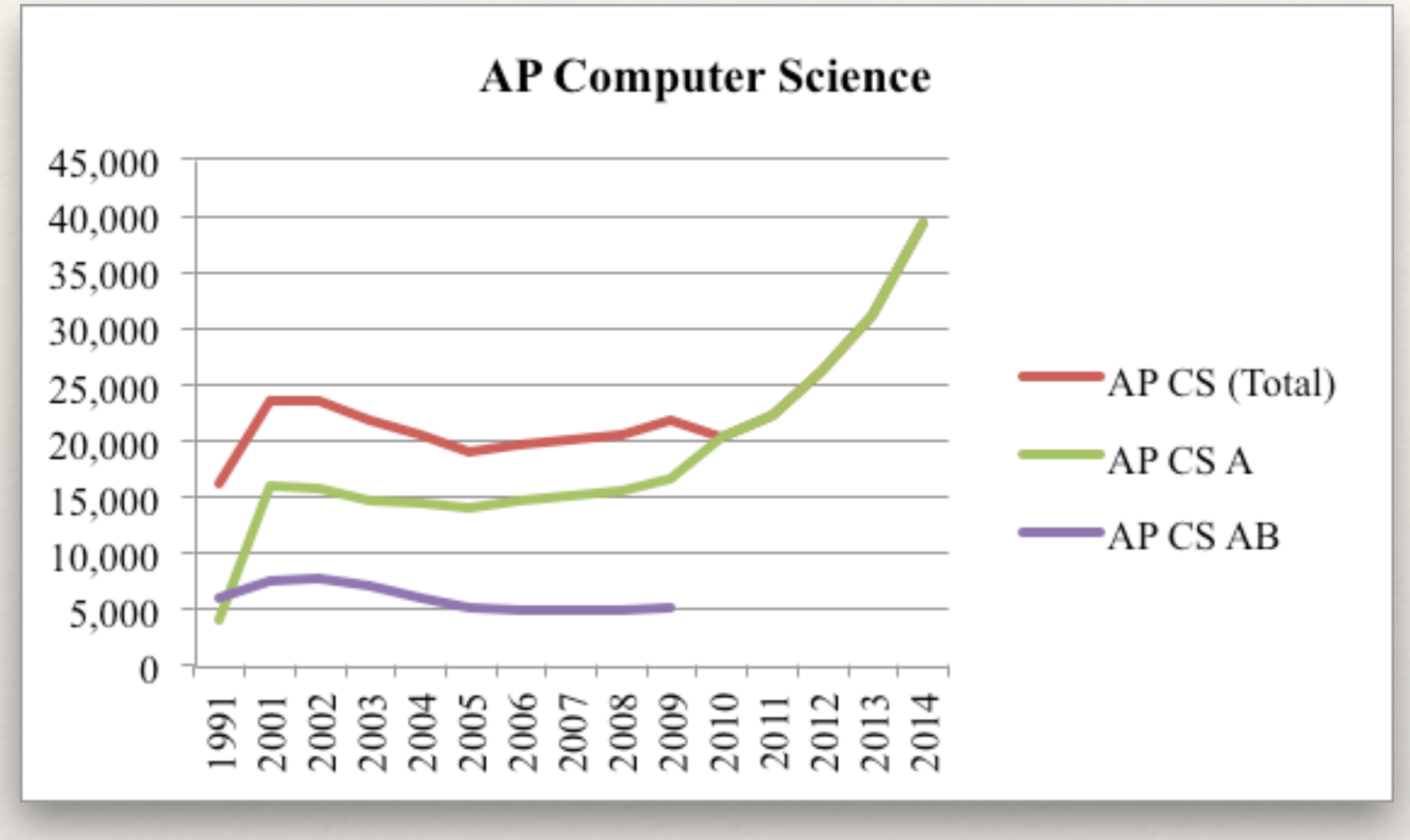
Future Work

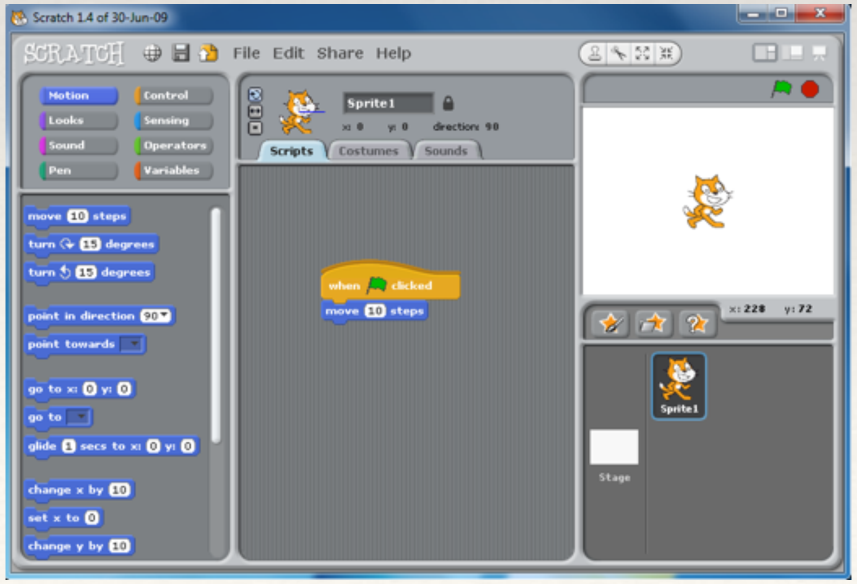
CS Education

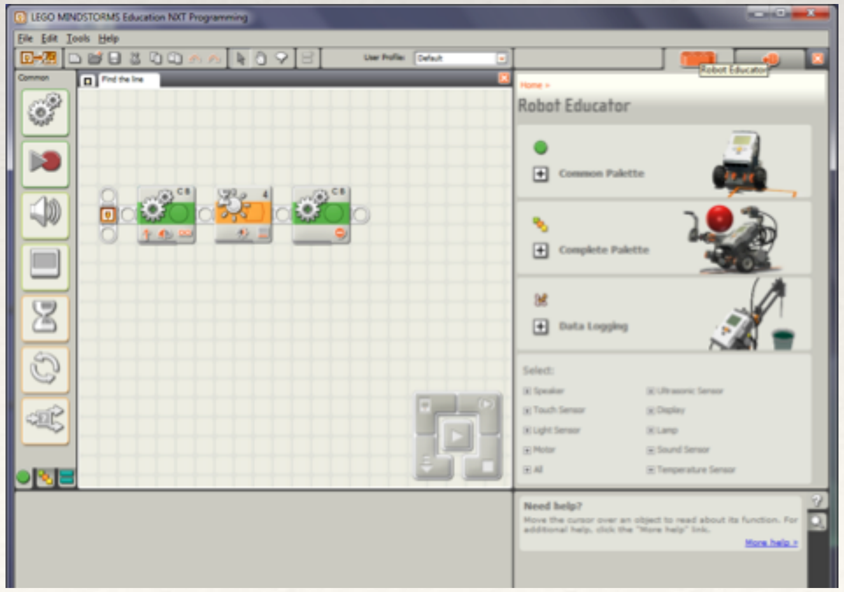


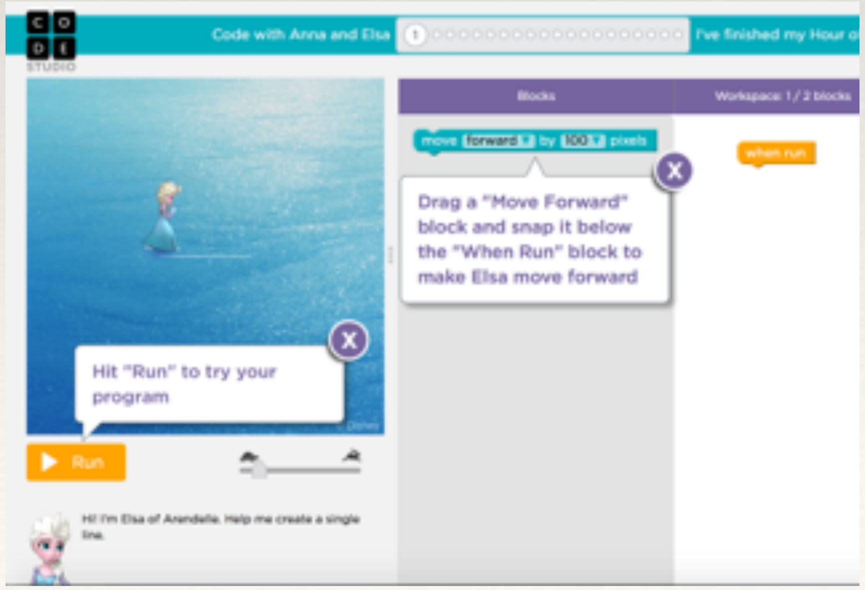
2014: 2,342,528 students took 4,176,200 AP exams

39,278 (1.7%) students participated in AP CS

AP CS A had fastest growing enrollment in 2013-2014!







Drag a "Move Forward" block and snap it below the "When Run" block to make Elsa move forward

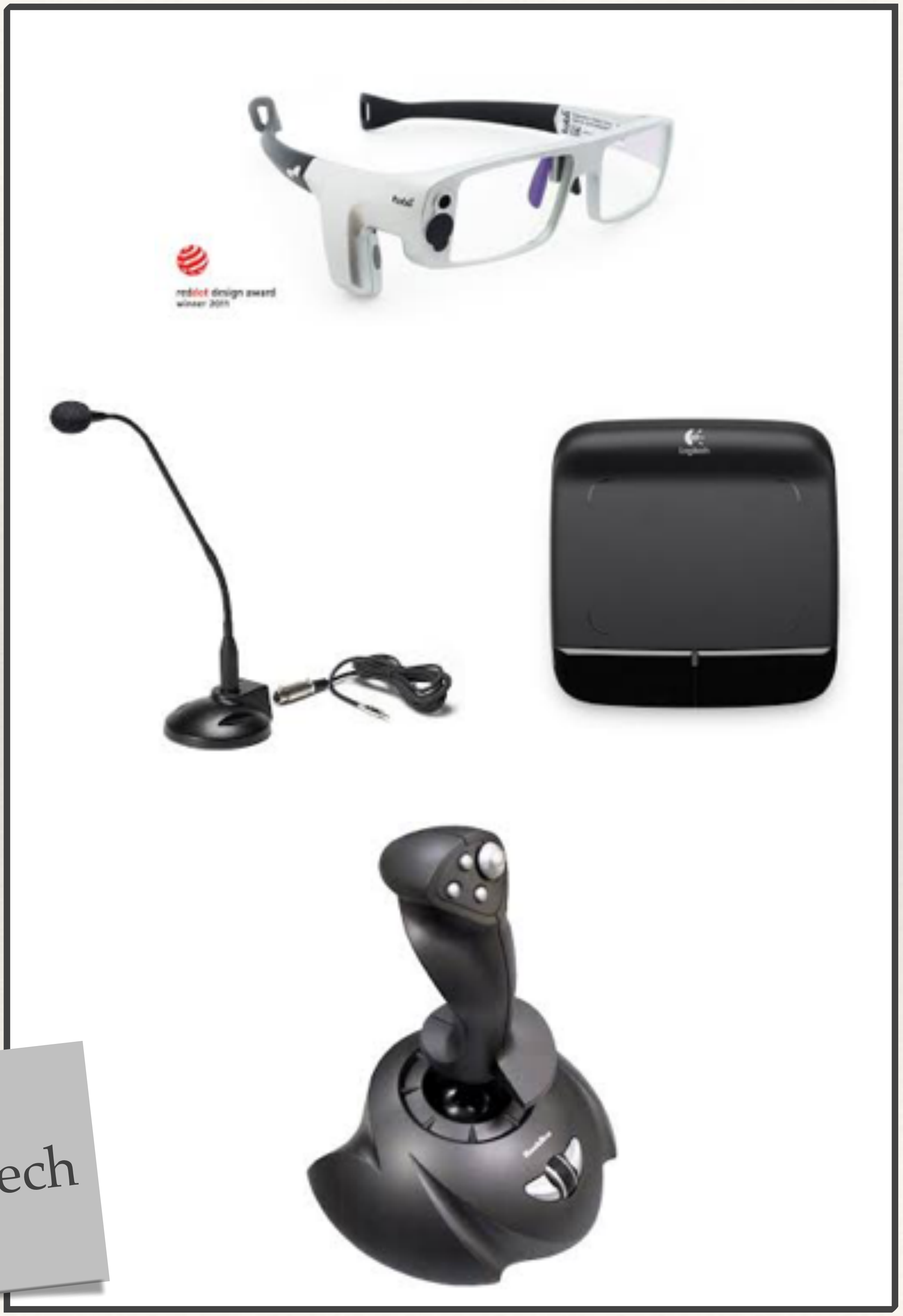
Hit "Run" to try your program

Hi! I'm Elsa of Arendelle. Help me create a single line.

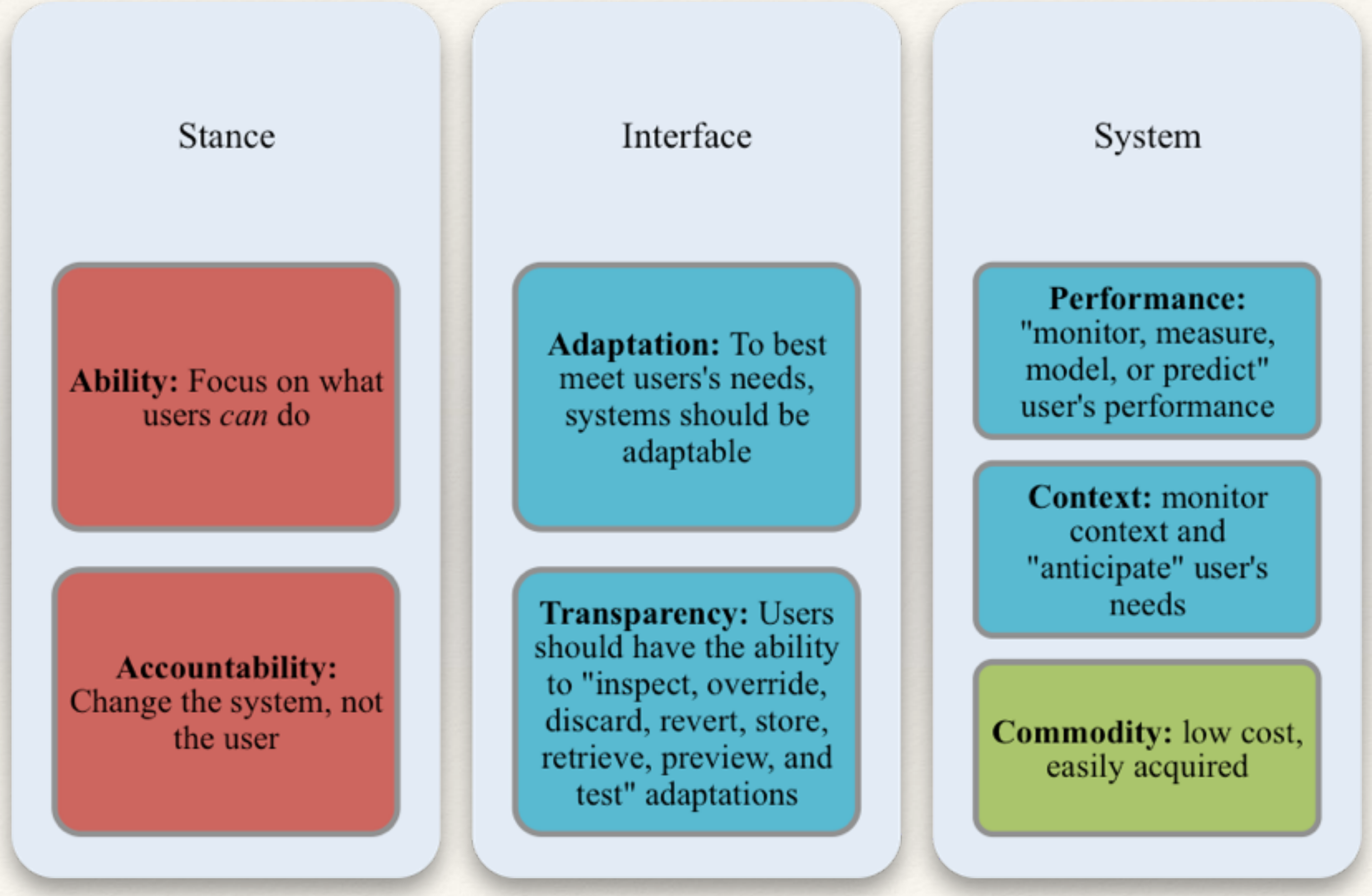
Accessibility Needs

Diagnosis	Number Impacted	Age of Onset
Spinal Cord Injury	250,000	56% occur between 16-30
Muscular Dystrophy	8,000 (males 5-24 years of	400-600 males are born with MD each
Multiple Sclerosis	250,000-350,000	20-40
Cerebral Palsy	800,000	10,000 babies born with CP each year

DO-IT
High School High Tech
Comp Camp



Ability-Based Design



Stance

Ability: Focus on what users *can* do

Accountability: Change the system, not the user

Interface

Adaptation: To best meet users's needs, systems should be adaptable

Transparency: Users should have the ability to "inspect, override, discard, revert, store, retrieve, preview, and test" adaptations

System

Performance: "monitor, measure, model, or predict" user's performance

Context: monitor context and "anticipate" user's needs

Commodity: low cost, easily acquired

Required

Recommended

Encouraged

Programming by Voice

```
for (int i = 0; i < 10; i++) {

}
```

for int i equals zero i less than ten i plus plus

4 int **eye** equals **0** **aye** less **then** ten i plus plus

Programming by Voice

Begel and Graham (2005, 2006)

- Spoken Java
- for SPEech EDitor (SPEED) Eclipse plug-in
- Grammar

Désilets et al. (2006)

- VoiceCode
- Grammar
- Code Navigation
- Error Correction

Hubbell et al. (2006)

- Voice-Activated Syntax-Directed Editor (VASDE)
- Interface
- Command-Based

Shaik et al. (2003)

- SpeechClipse
- Command-Based
- Java Robot

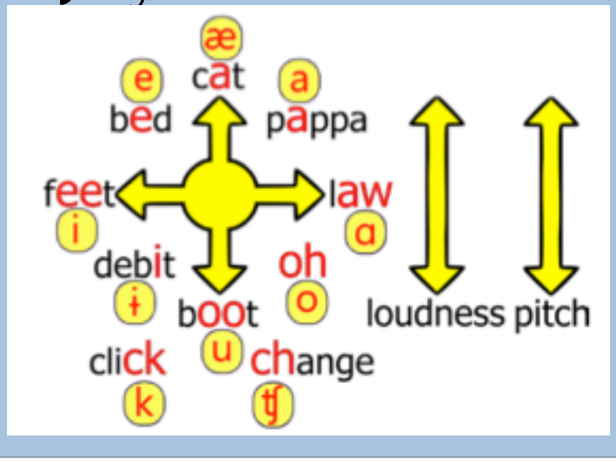
Interface Interaction

Dai et al. (2004)

- Grid-Based Navigation
- Nine-Cursor Grid

Harada et al. (2009)

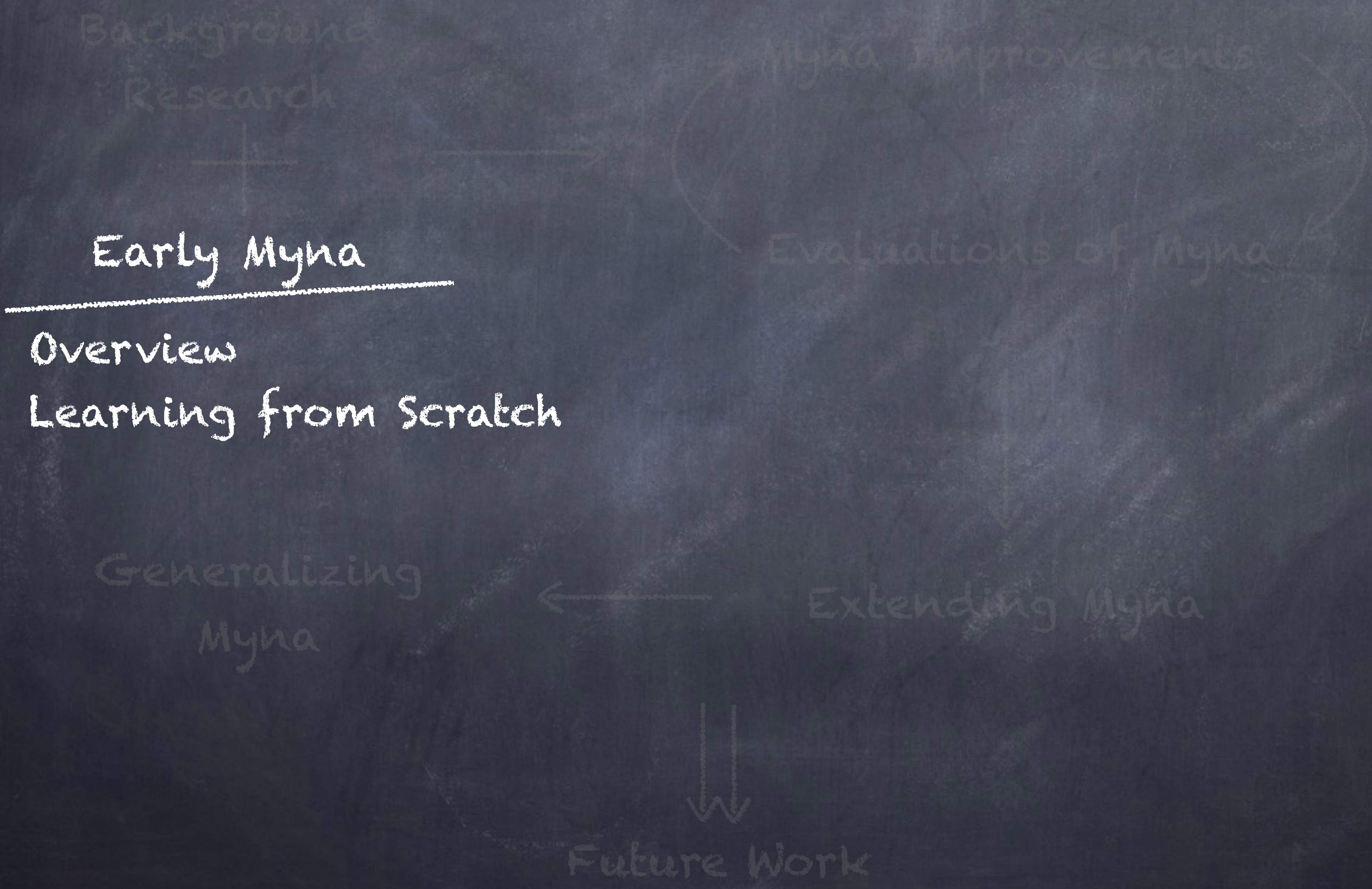
- Vocal Joystick



Raman (1996)

- Emacspeak
- Vocalize content on screen

Dissertation Roadmap



Background Research

Myna Improvements

Evaluations of Myna

Early Myna

Overview

Learning from Scratch

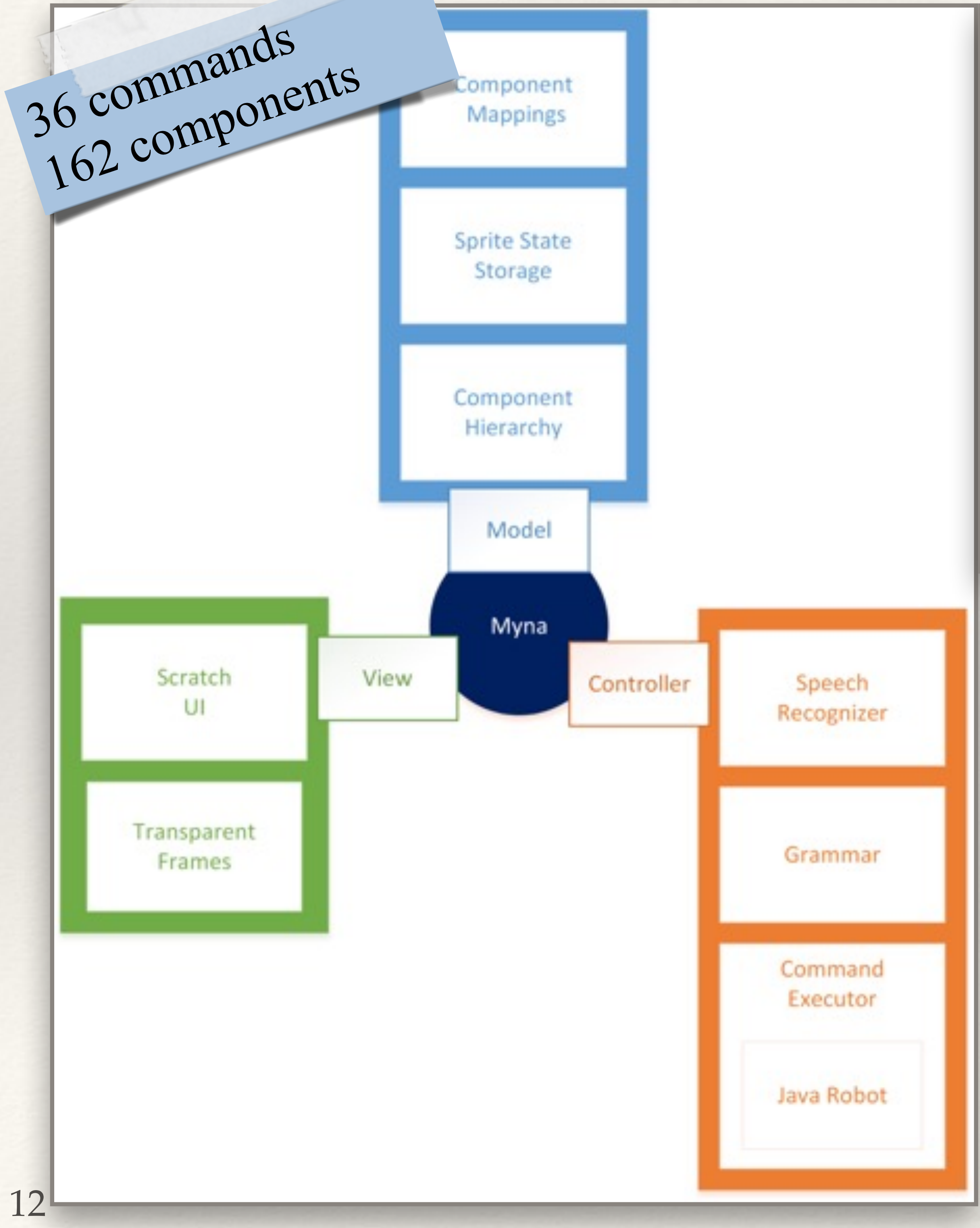
Extending Myna

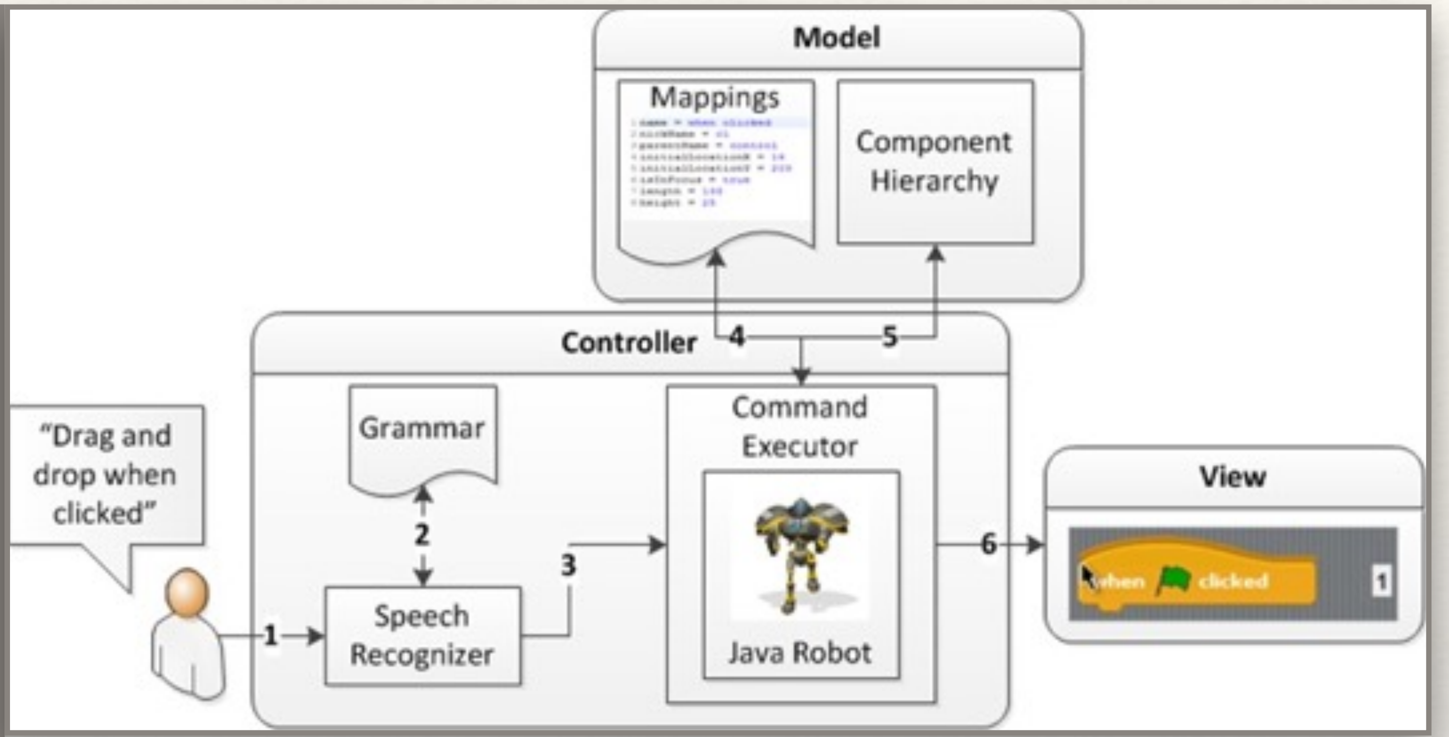
Generalizing Myna

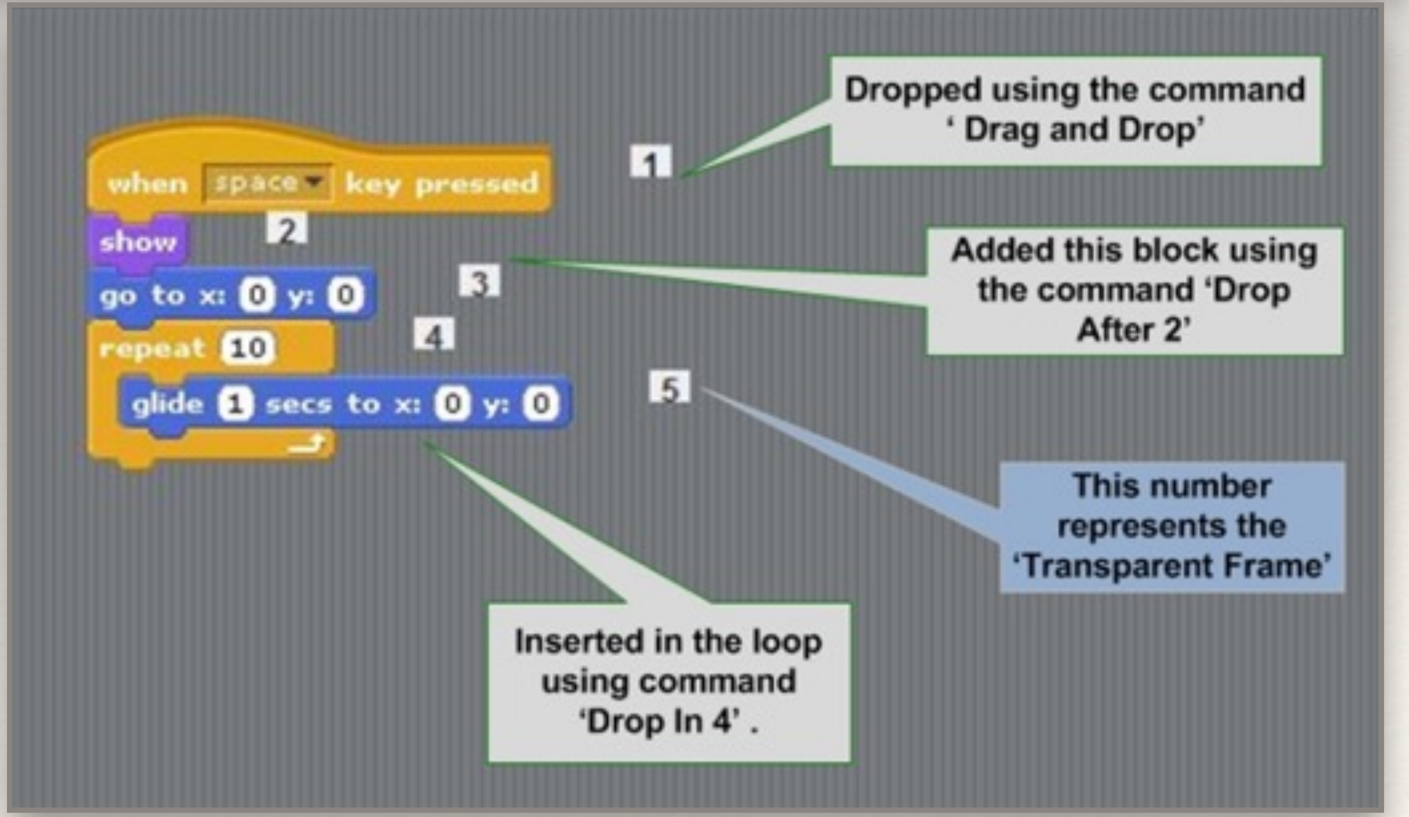
Future Work

Overview of Early Myna

36 commands
162 components







```
when space key pressed
show
go to x: 0 y: 0
repeat 10
    glide 1 secs to x: 0 y: 0
```

1 Dropped using the command ' Drag and Drop'

2

3 Added this block using the command 'Drop After 2'

4 Inserted in the loop using command 'Drop In 4' .

5 This number represents the 'Transparent Frame'

Learning from Scratch

	Extra Blocks	Not Control Block
Part 1	31%	15%
Part 2	10%	4%

Users felt dragging extra blocks onto the screen helped with problem solving.

19% (all students) spent time manipulating images

Dissertation Roadmap

Myna Improvements

GUI Mapping Challenges

Requirements/Limitations/
Assumptions

Background Research

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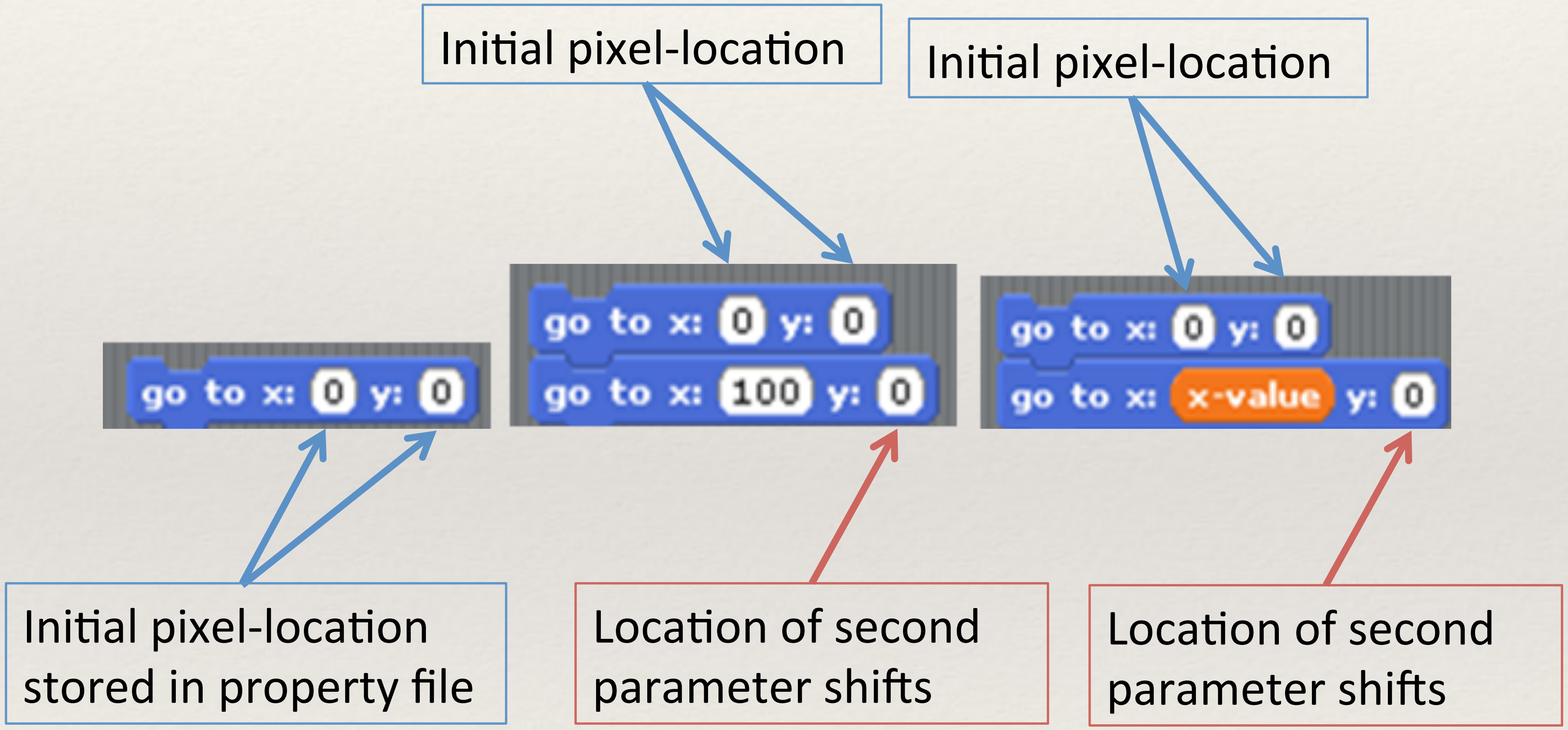
GUI Mapping Challenges

Parameters - Horizontal Expansion



```
go to x: 0 y: 0
```

```
go to x: 0 y: 0
go to x: 100 y: 0
```

```
go to x: 0 y: 0
go to x: x-value y: 0
```

Initial pixel-location

Initial pixel-location

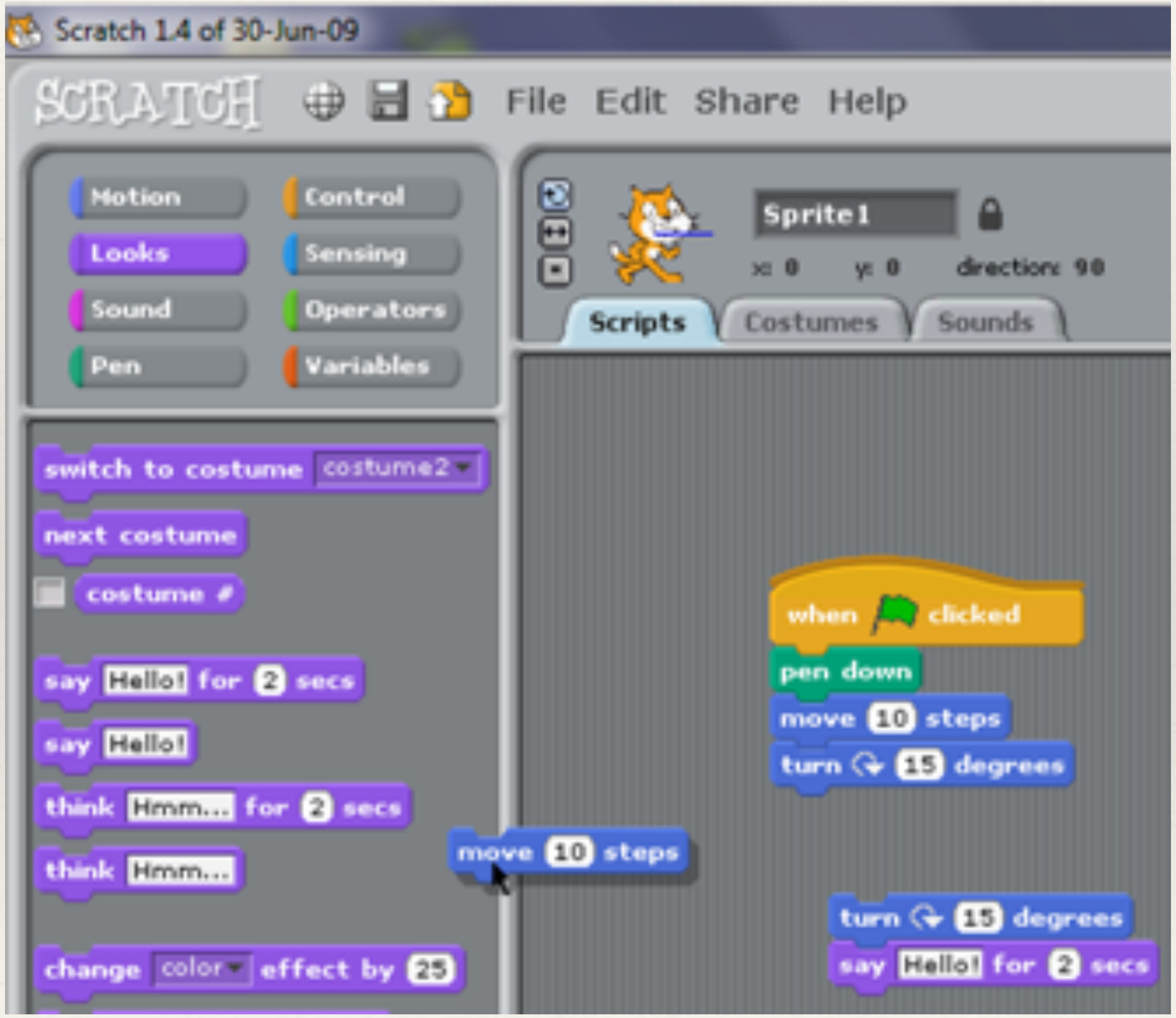
Initial pixel-location stored in property file

Location of second parameter shifts

Location of second parameter shifts

GUI Mapping Challenges

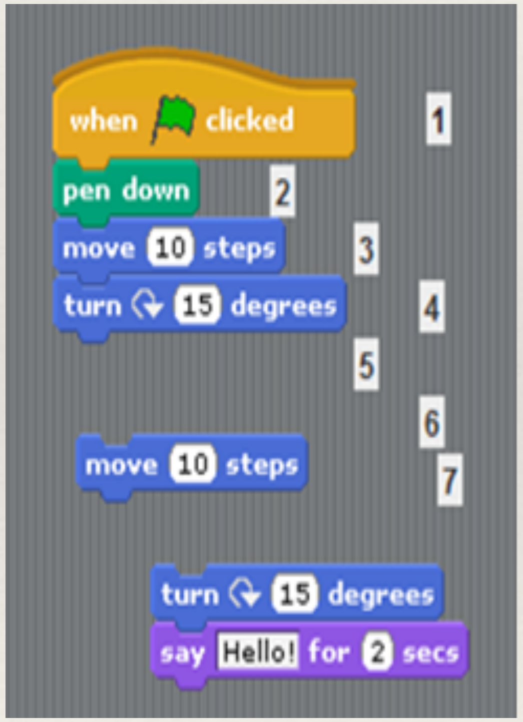
Delete



GUI Mapping Challenges

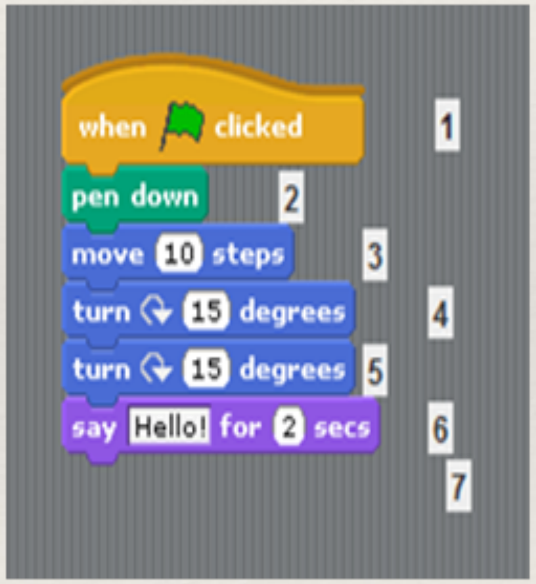
Delete

1. Separate the blocks



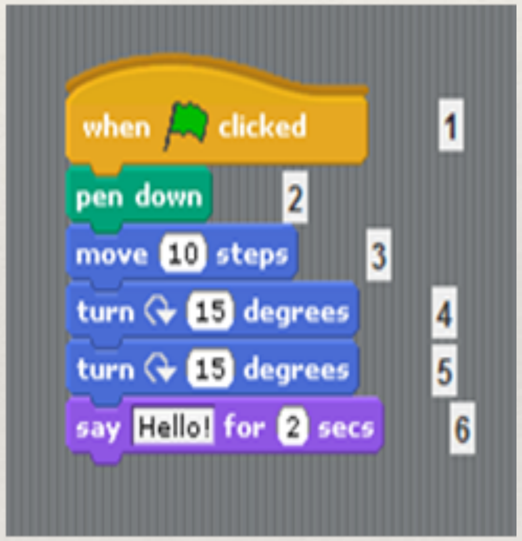
```
when ⚑ clicked            1
pen down           2
move 10 steps          3
turn ↻ 15 degrees          4
                       5
                           6
  move 10 steps              7

        turn ↻ 15 degrees
        say Hello! for 2 secs
```

2. Drag block to the side
3. Reassemble blocks



```
when ⚑ clicked            1
pen down           2
move 10 steps          3
turn ↻ 15 degrees          4
turn ↻ 15 degrees 5
say Hello! for 2 secs      6
                             7
```

4. Renumber blocks

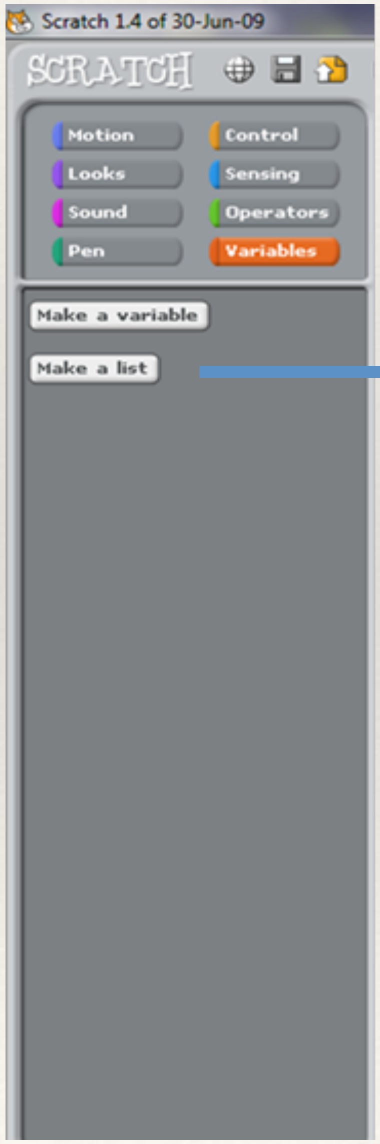


```
when ⚑ clicked            1
pen down           2
move 10 steps          3
turn ↻ 15 degrees          4
turn ↻ 15 degrees          5
say Hello! for 2 secs       6
```

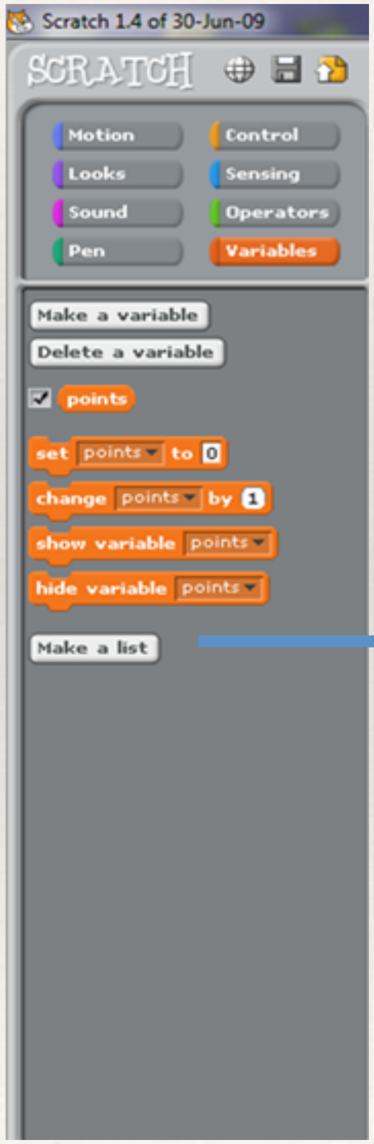
GUI Mapping Challenges

Variables - Dynamic GUI Changes

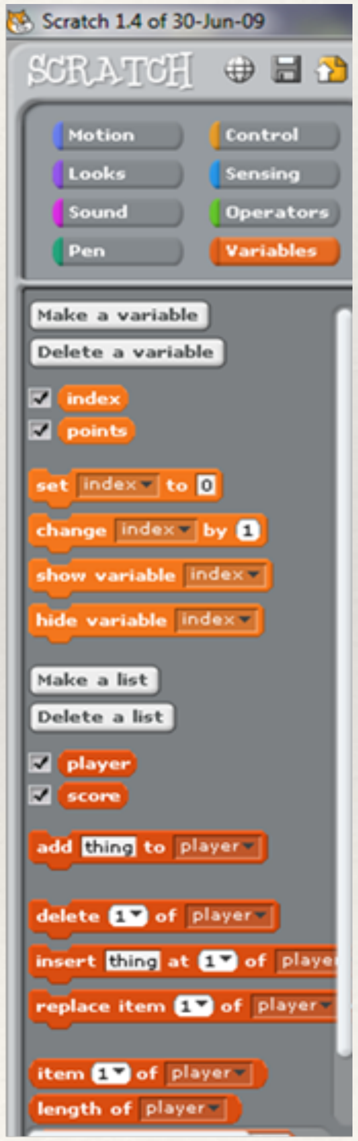
Original View



New Variable

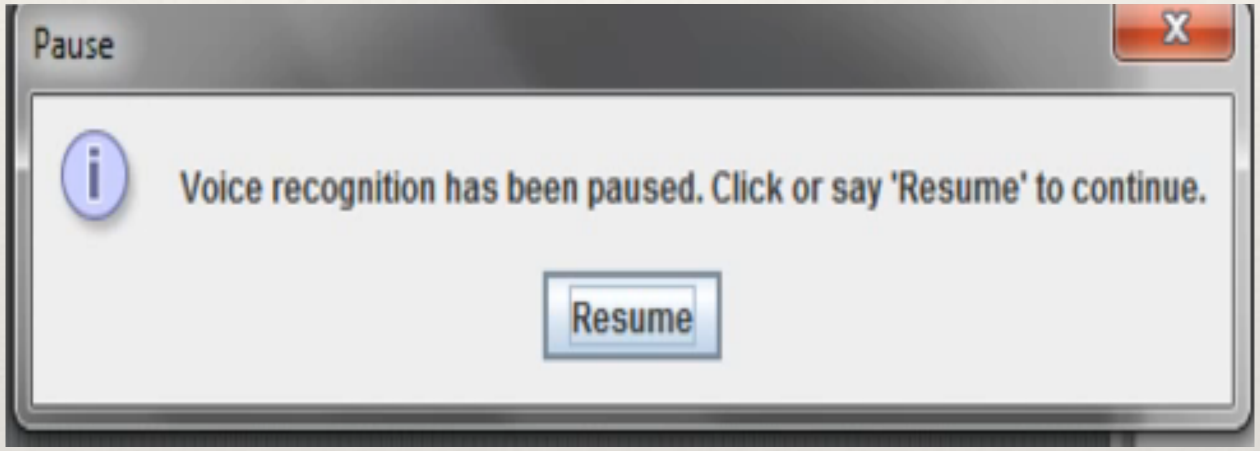


New List



GUI Mapping Challenges

Pause

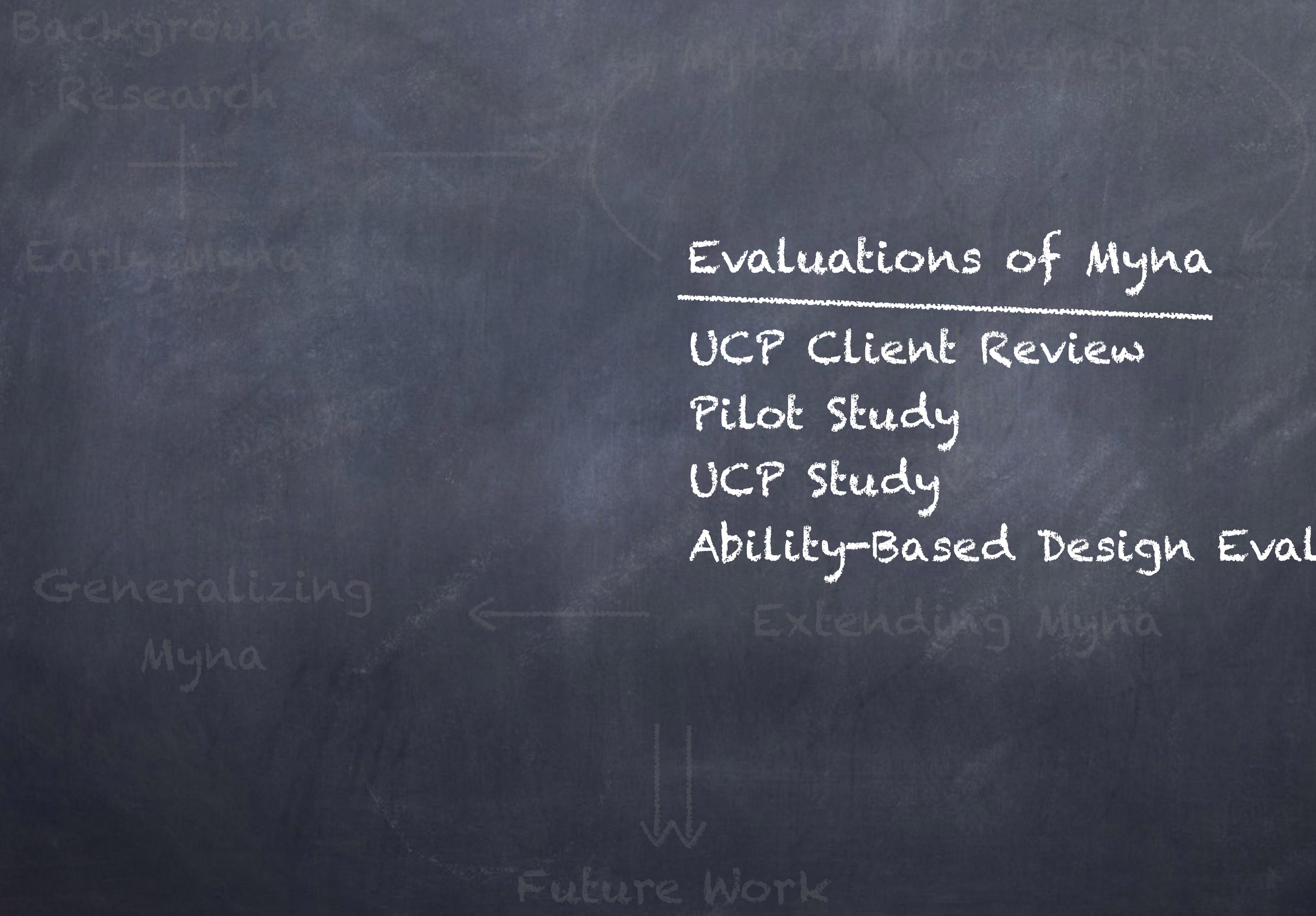


Voice recognition has been paused. Click or say 'Resume' to continue.

Requirements/Limitations/Assumptions

- **Requirements**
  - Platform-independent
  - A directional microphone (roughly $30)
  - Quiet environment
- **Limitations**
  - Editing parameters
  - Right-Click
  - Variables and Lists
- **Assumptions**
  - Speak articulately
  - Cognitive ability of typically developed 8 year old

Dissertation Roadmap



Background Research

+

Early Myna

Myna Improvements

Generalizing Myna

Extending Myna

Future Work

Evaluations of Myna

UCP Client Review

Pilot Study

UCP Study

Ability-Based Design Evaluation

UCP Client Review

Client 1	❖ Cerebral Palsy, severe impairment ❖ Used laptop to communicate ❖ Able to test and approved of Myna
Client 2	❖ Cerebral Palsy, limited communication ❖ Limited vocal ability prevented use but approved of idea
Client 3	❖ Quadriplegic ❖ Able to test and approved of Myna

UCP United Cerebral Palsy of Greater Birmingham

Life without limits for people with disabilities

Pilot Study

- Five graduate CS students
- Observed 3 programs written using mouse/keyboard
- Observed 3 programs written using Myna (voice)
- Participants felt Myna was easy to learn
- Participants felt satisfied after using Myna

Observation	Program 1	Program 2	Program 3
Type A - Participant stated incorrect vocal command (Average count)	0.8	1	0.2
Type B - Participant stated incorrect Scratch command (Average count)	0.6	0	0.4
Type C - Speech recognition was inaccurate (Average count)	0.75	2.4	1.8
Type D - Myna placed the block in the incorrect location (Average count)	1.2	0.8	0.8
Time to complete with Scratch (Average seconds)	114.2	83.2	88.6
Time to complete with Myna (Average seconds)	98.6	113.6	112.8

UCP Study

Observation	Session 1	Session 2	Session 3	Session 4
Type A - Participant stated incorrect vocal command	0	1	0	0
Type B - Participant stated incorrect Scratch command	0	0	0	0
Type C - Speech recognition was inaccurate	1	0	0	0
Type D - Myna placed the block in the incorrect location	0	2	0	0

Observation	Session 1	Session 2
Type A	0	0
Type B	0	0
Type C	5*	2
Type D	0	2

UCP United Cerebral Palsy of Greater Birmingham

Life without limits for people with disabilities

Ability-Based Design Evaluation

Principle	Myna Meets Principle
Ability	✓
Accountability	Parameters too complicated
Adaptation	Grammar Customization
Transparency	More communication
Performance	✓
Context	Dynamic Grammar, Help Messages
Commodity	✓

Dissertation Roadmap

Background Research
Early Myna
Generalizing Myna
Extending Myna
Future Work

Myna Improvements

Parameters

Grammar Customization

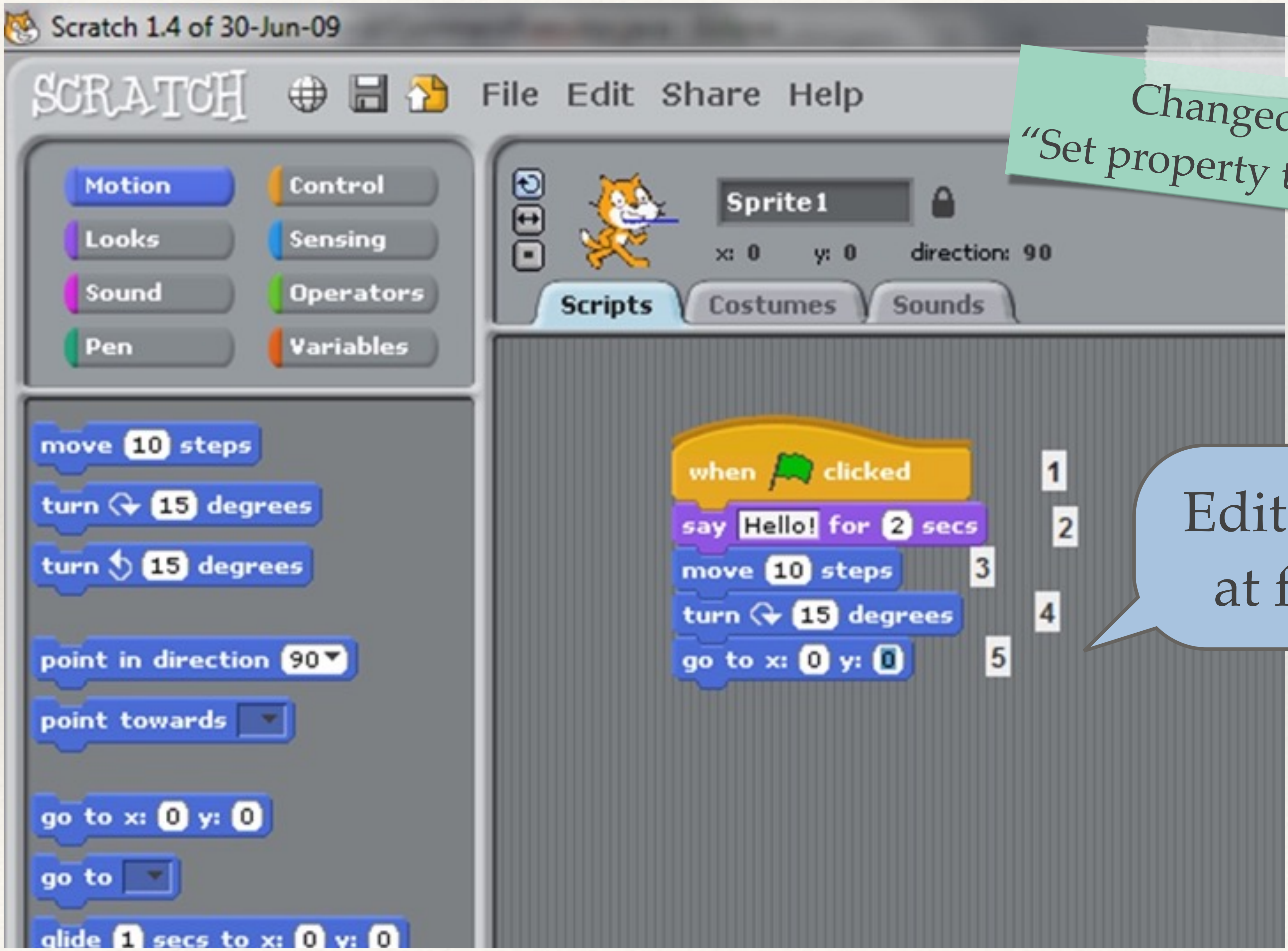
Delete and Start Over

Undo

Speech Recognition Display

Help Messages

Parameters

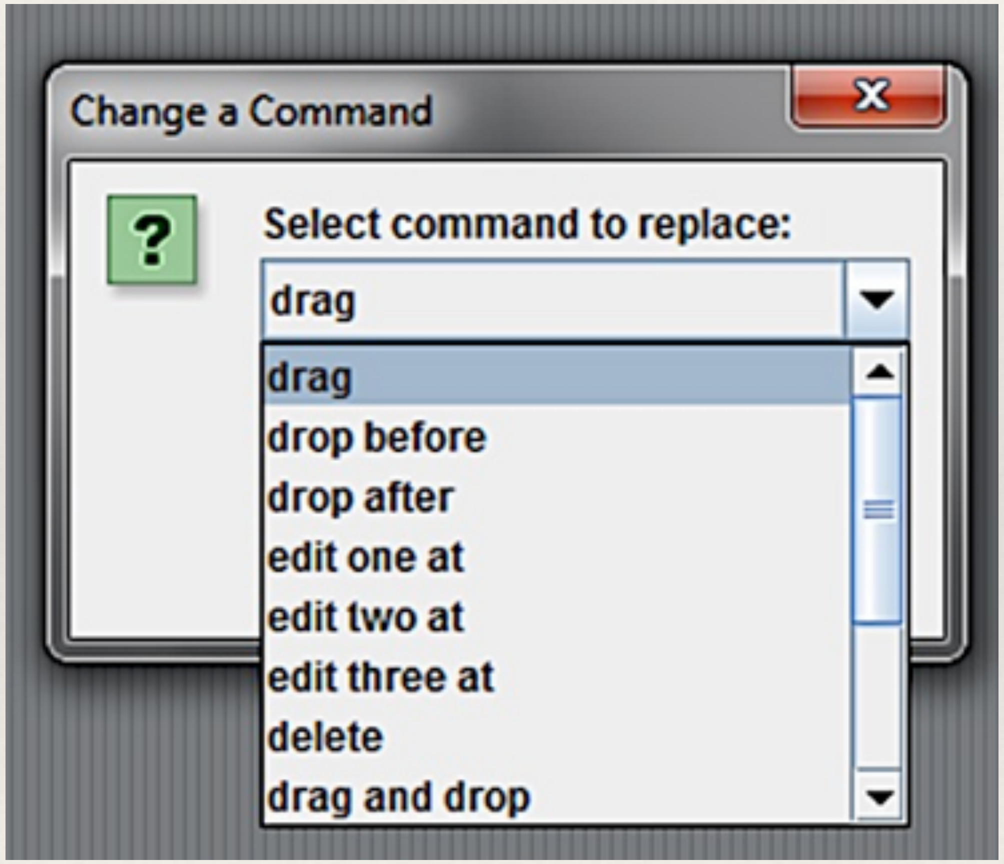


```
when 🏁 clicked            1
say Hello! for 2 secs      2
move 10 steps              3
turn ↻ 15 degrees          4
go to x: 0 y: 0            5
```

Changed from
"Set property two at five"

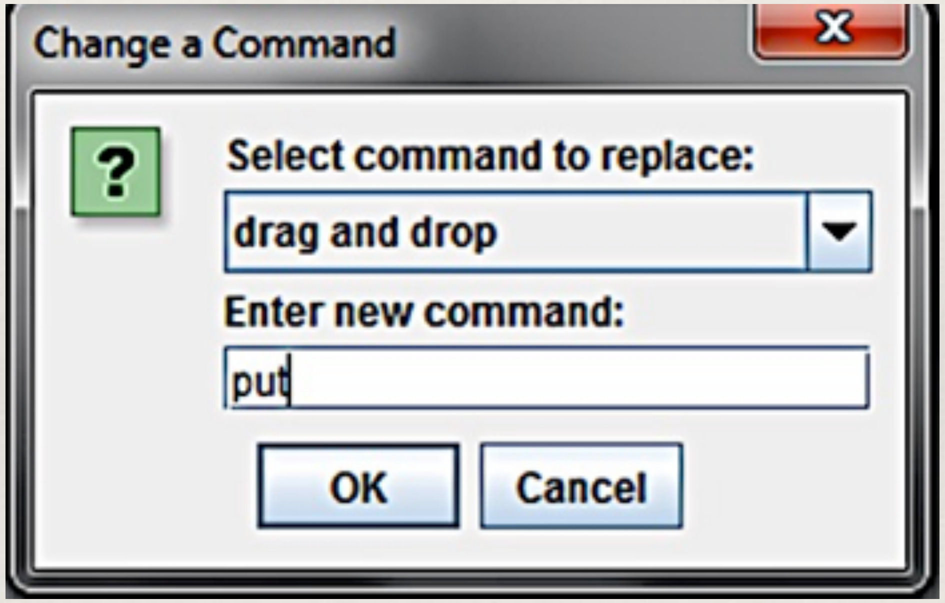
Edit two
at five

Grammar Customization



Change a Command

Select command to replace: drag

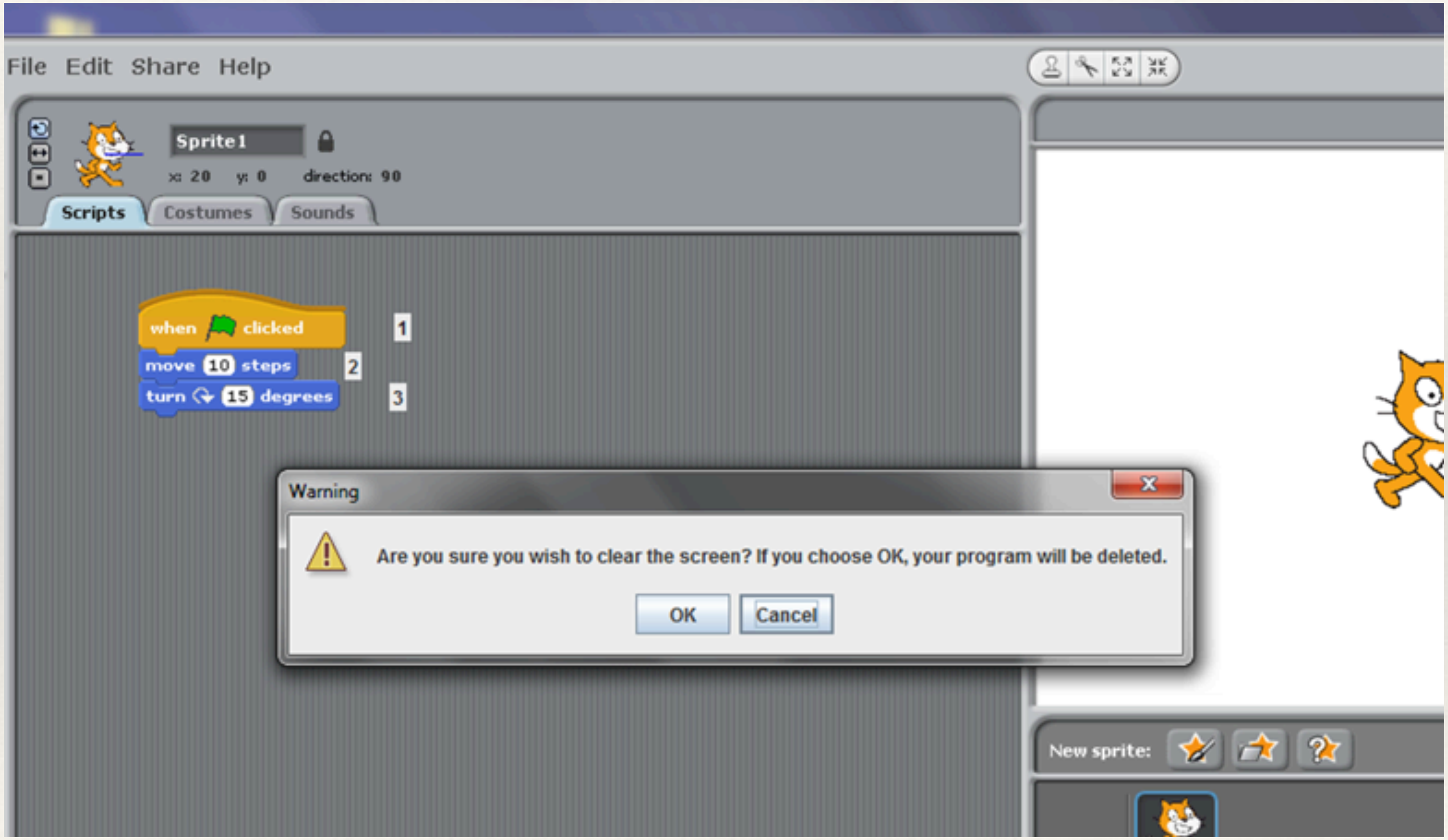


Change a Command

Select command to replace: drag and drop

Enter new command: put

Delete and Start Over

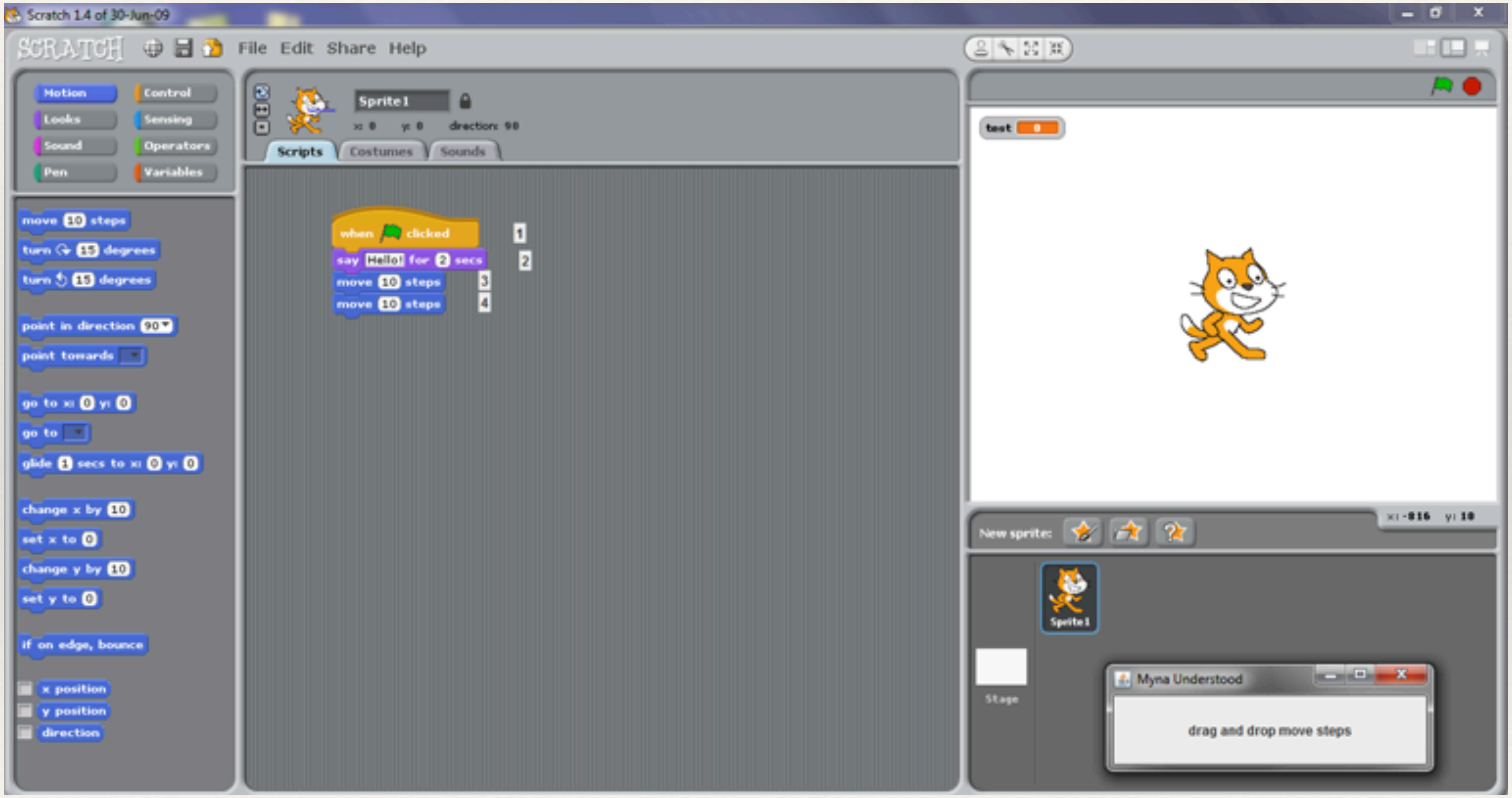


Warning

Are you sure you wish to clear the screen? If you choose OK, your program will be deleted.

OK Cancel

Speech Recognition Display

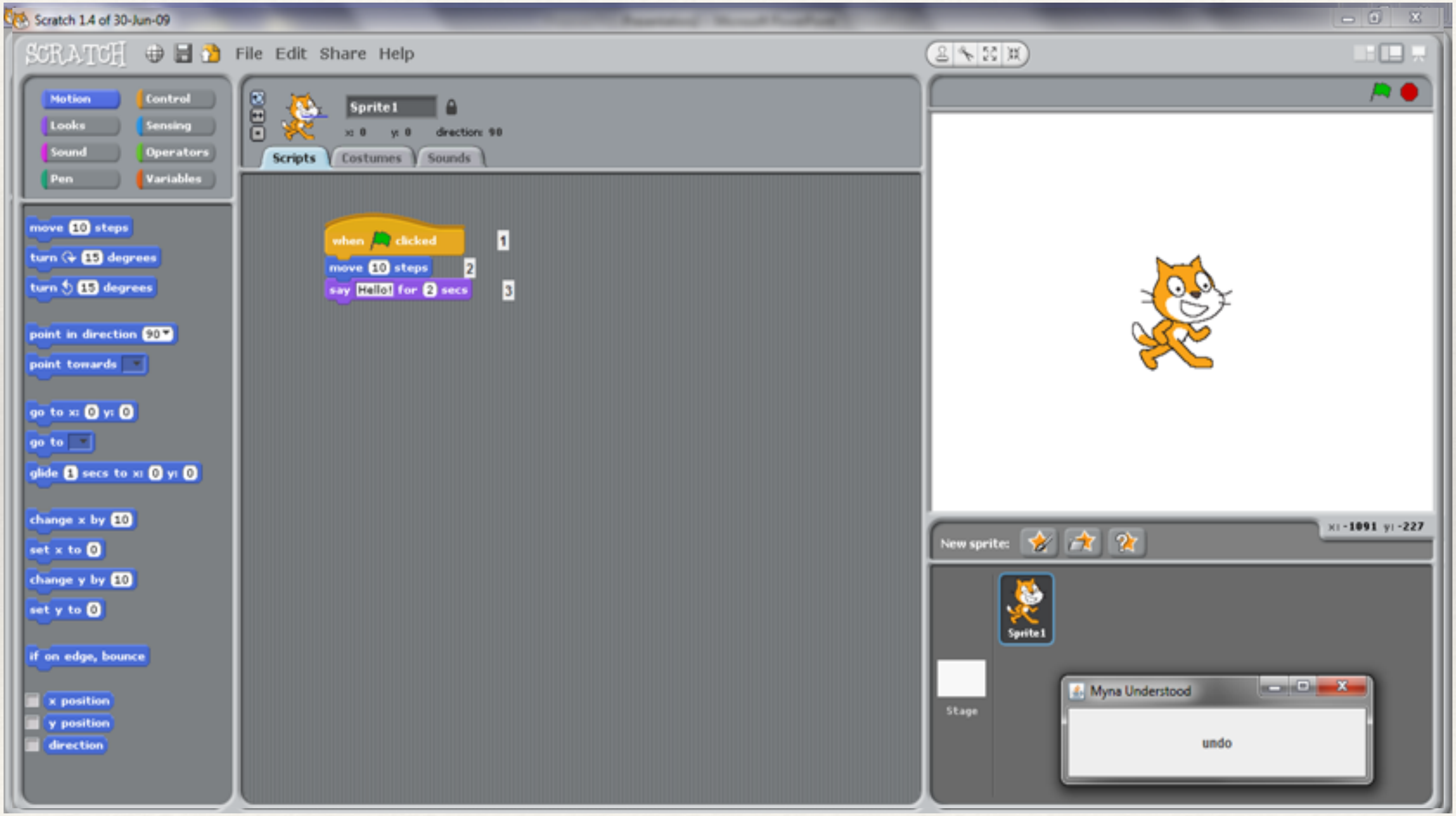


```
when [flag] clicked      1
say Hello! for 2 secs    2
move 10 steps            3
move 10 steps            4
```

Myna Understood

drag and drop move steps

Undo

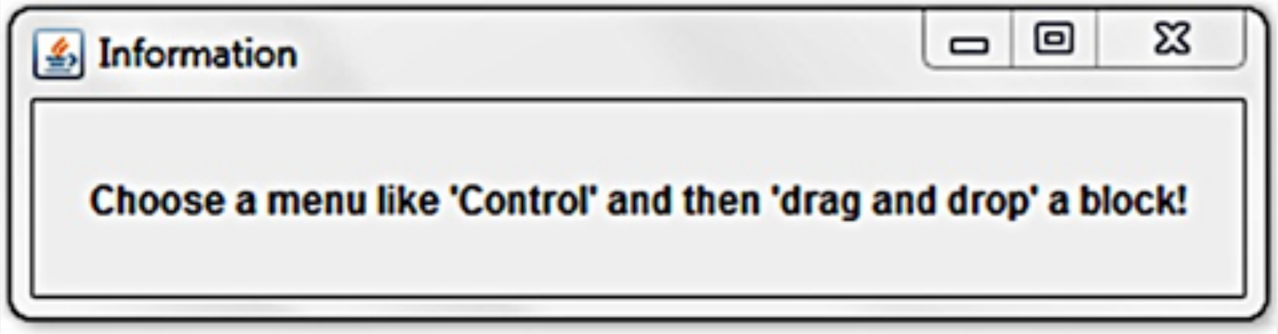


```
when 🏁 clicked   1
move 10 steps     2
say Hello! for 2 secs   3
```

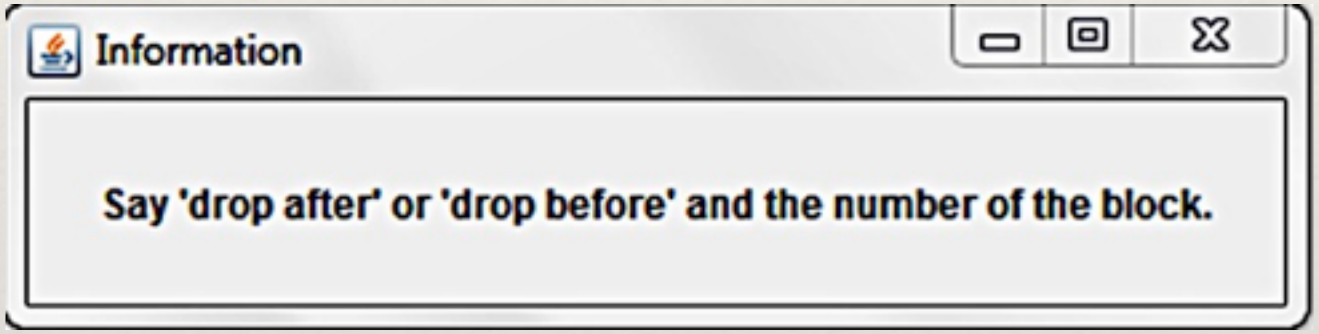
Myna Understood

undo

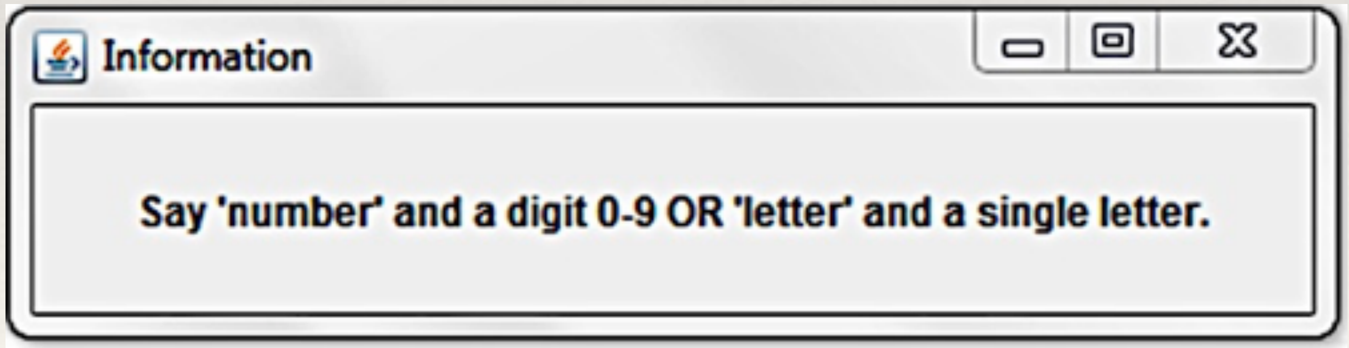
Help Messages



Choose a menu like 'Control' and then 'drag and drop' a block!

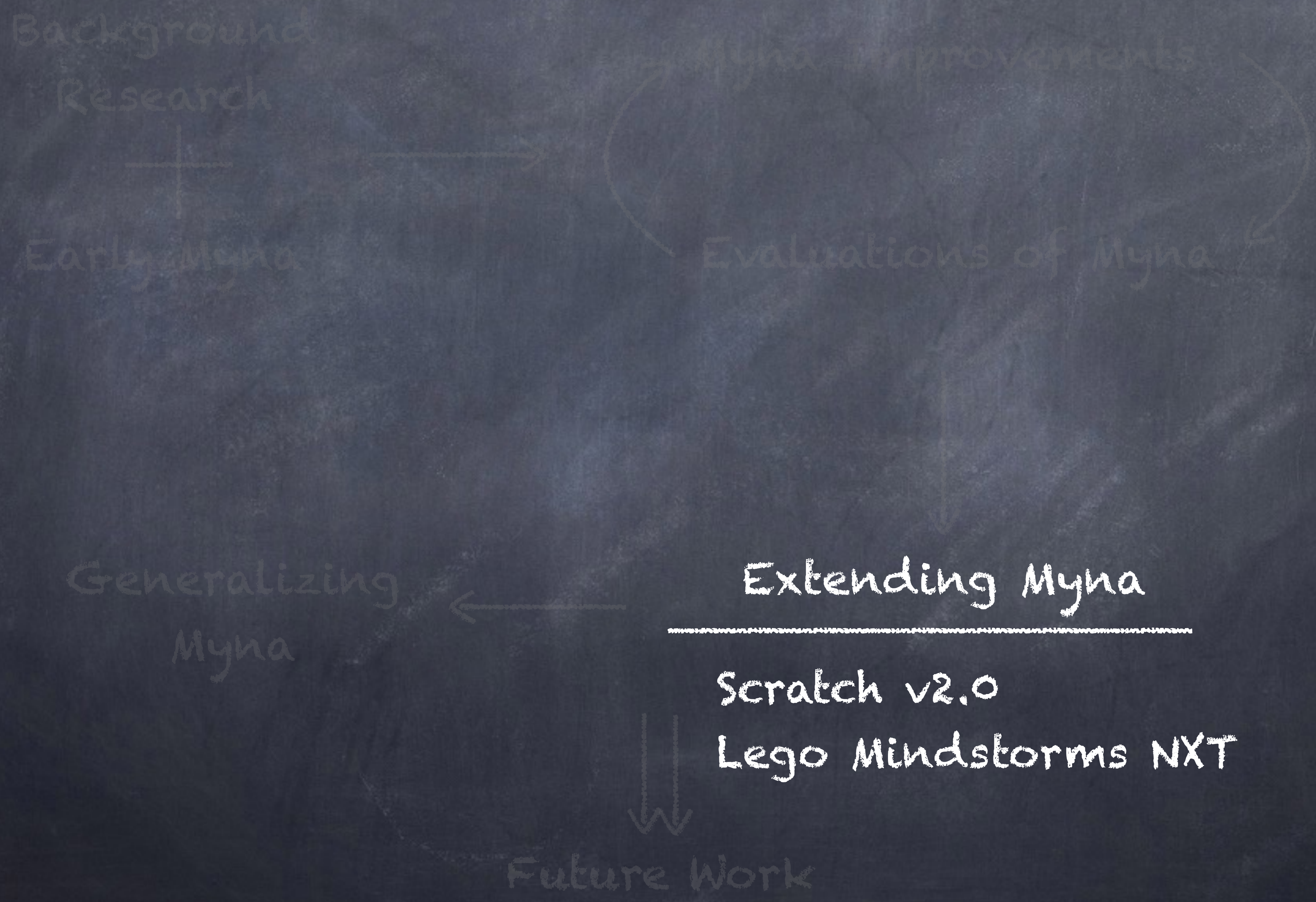


Say 'drop after' or 'drop before' and the number of the block.



Say 'number' and a digit 0-9 OR 'letter' and a single letter.

Dissertation Roadmap



Background Research

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Extending Myna

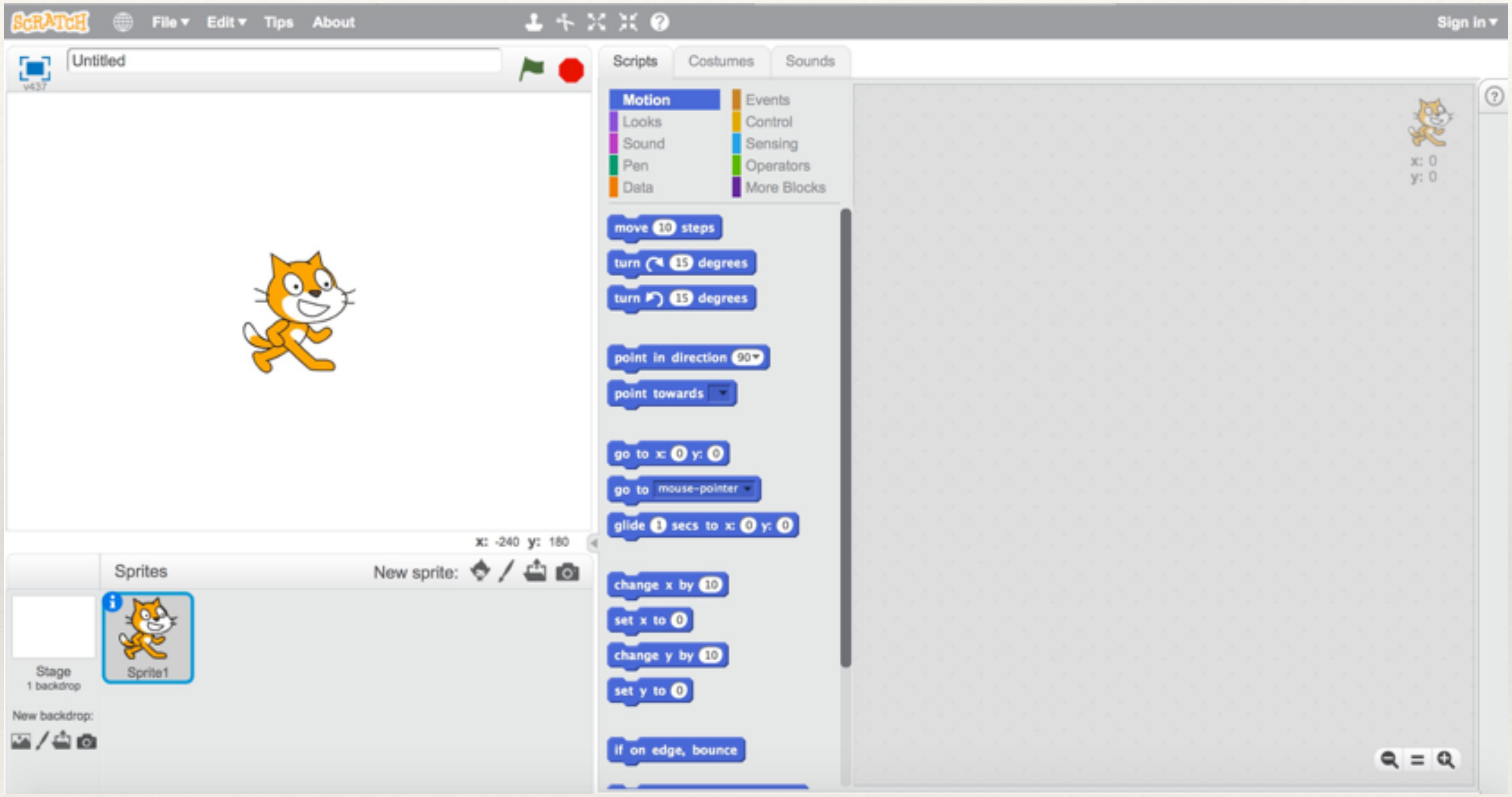
Scratch v2.0

Lego Mindstorms NXT

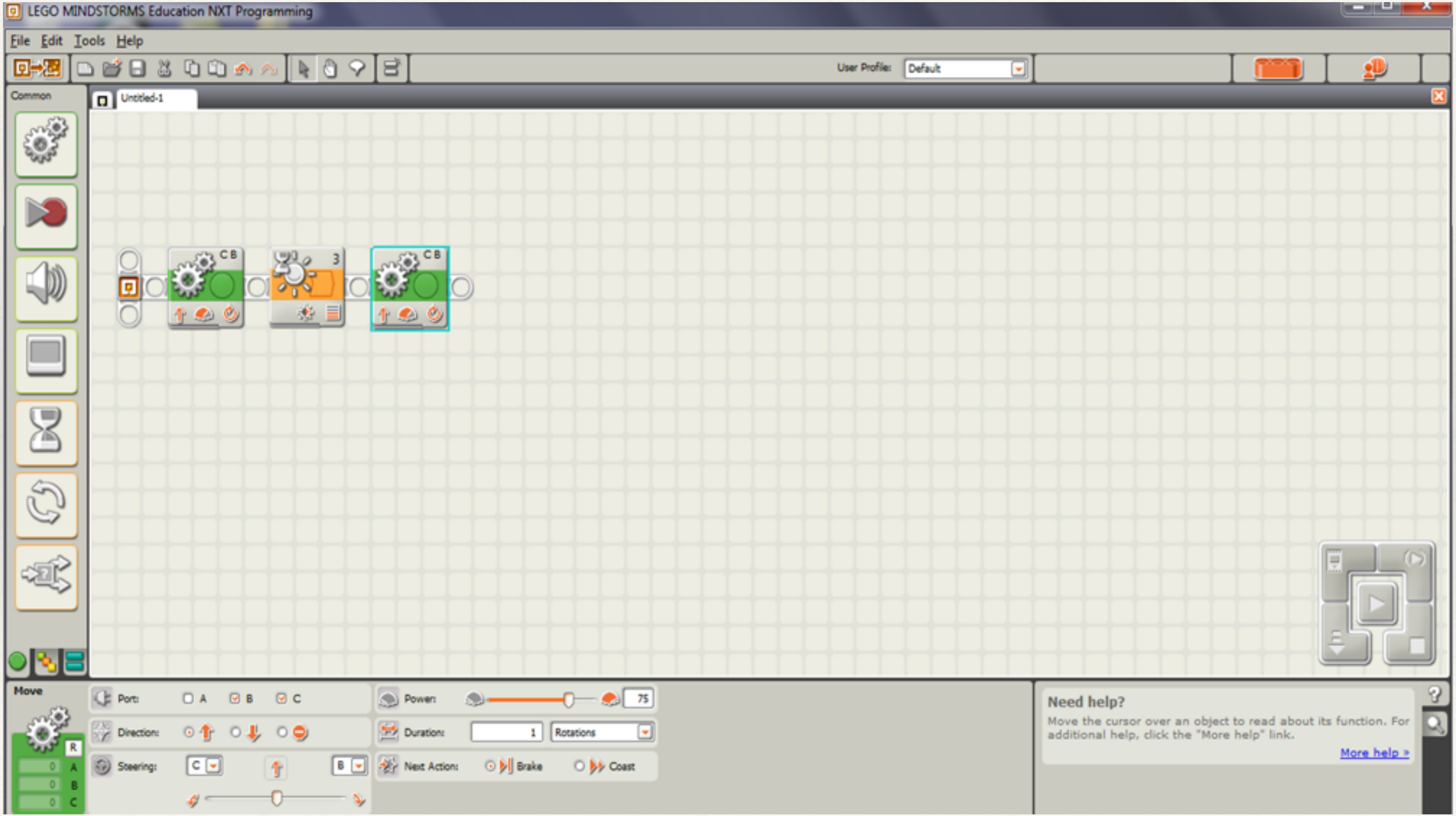
Generalizing Myna

Future Work

Scratch v2.0


SCRATCH
File
Edit
Tips
About
Sign in
Untitled
v437
Scripts
Costumes
Sounds
Motion
Looks
Sound
Pen
Data
Events
Control
Sensing
Operators
More Blocks
move 10 steps
turn ↻ 15 degrees
turn ↺ 15 degrees
point in direction 90
point towards
go to x: 0 y: 0
go to mouse-pointer
glide 1 secs to x: 0 y: 0
change x by 10
set x to 0
change y by 10
set y to 0
if on edge, bounce
x: -240 y: 180
x: 0
y: 0
Sprites
New sprite:
Stage
1 backdrop
New backdrop:
Sprite1

Lego Mindstorms NXT



Port: □ A ☑ B ☑ C

Direction: ● ↑ ○ ↓ ○ ⊖

Steering: C B

Power: 75

Duration: 1 Rotations

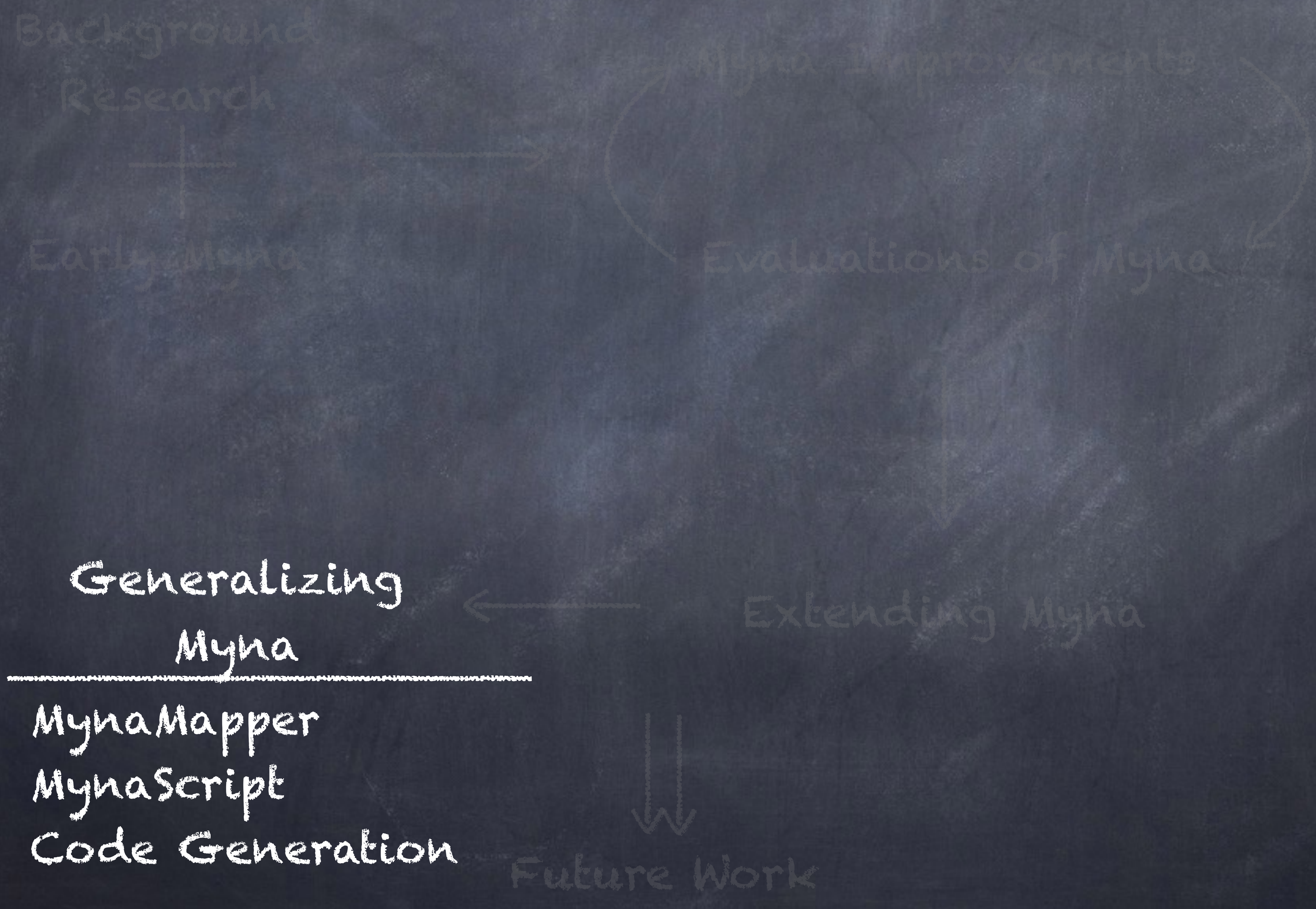
Next Action: ● Brake ○ Coast

Need help?

Move the cursor over an object to read about its function. For additional help, click the "More help" link.

More help »

Dissertation Roadmap



Background Research

+

Early Myna

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Generalizing Myna

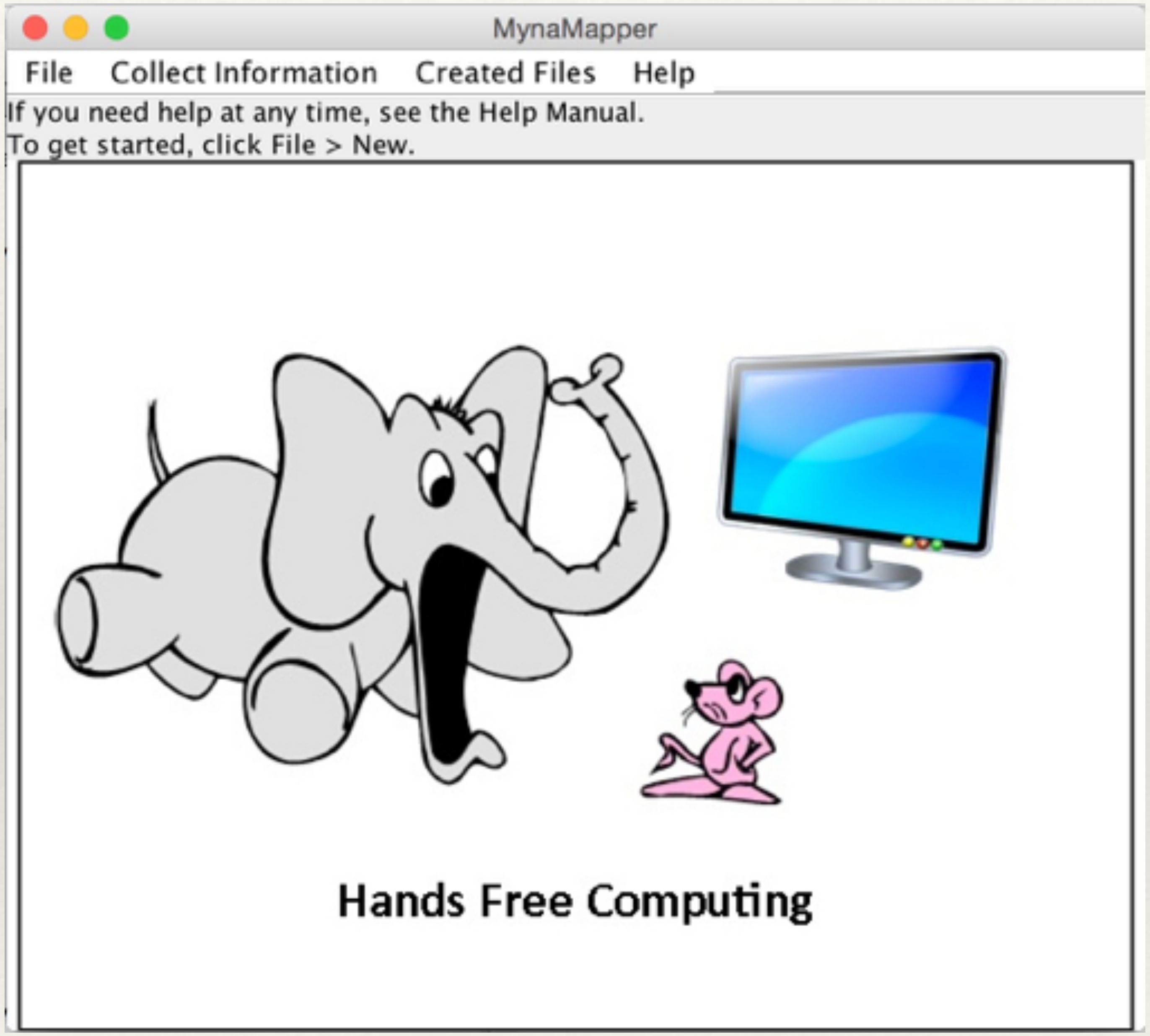
MynaMapper

MynaScript

Code Generation

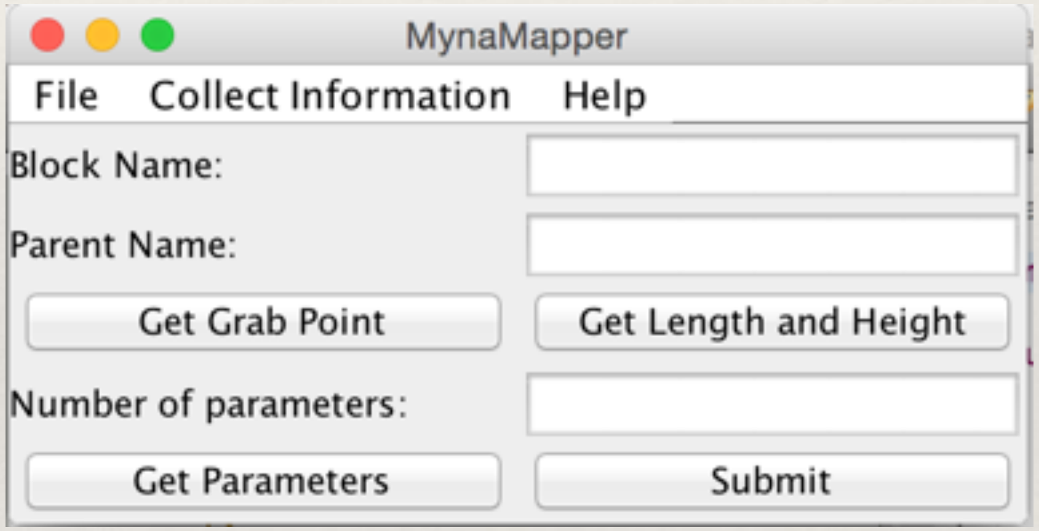
Future Work

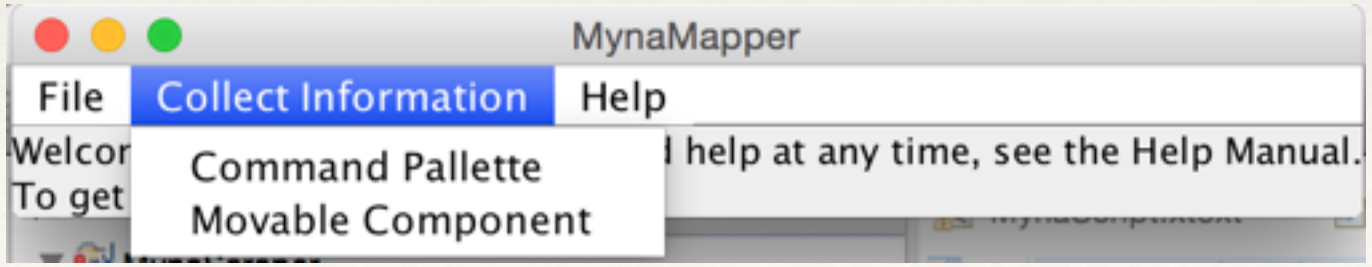
MynaMapper



If you need help at any time, see the Help Manual.
To get started, click File > New.

Hands Free Computing

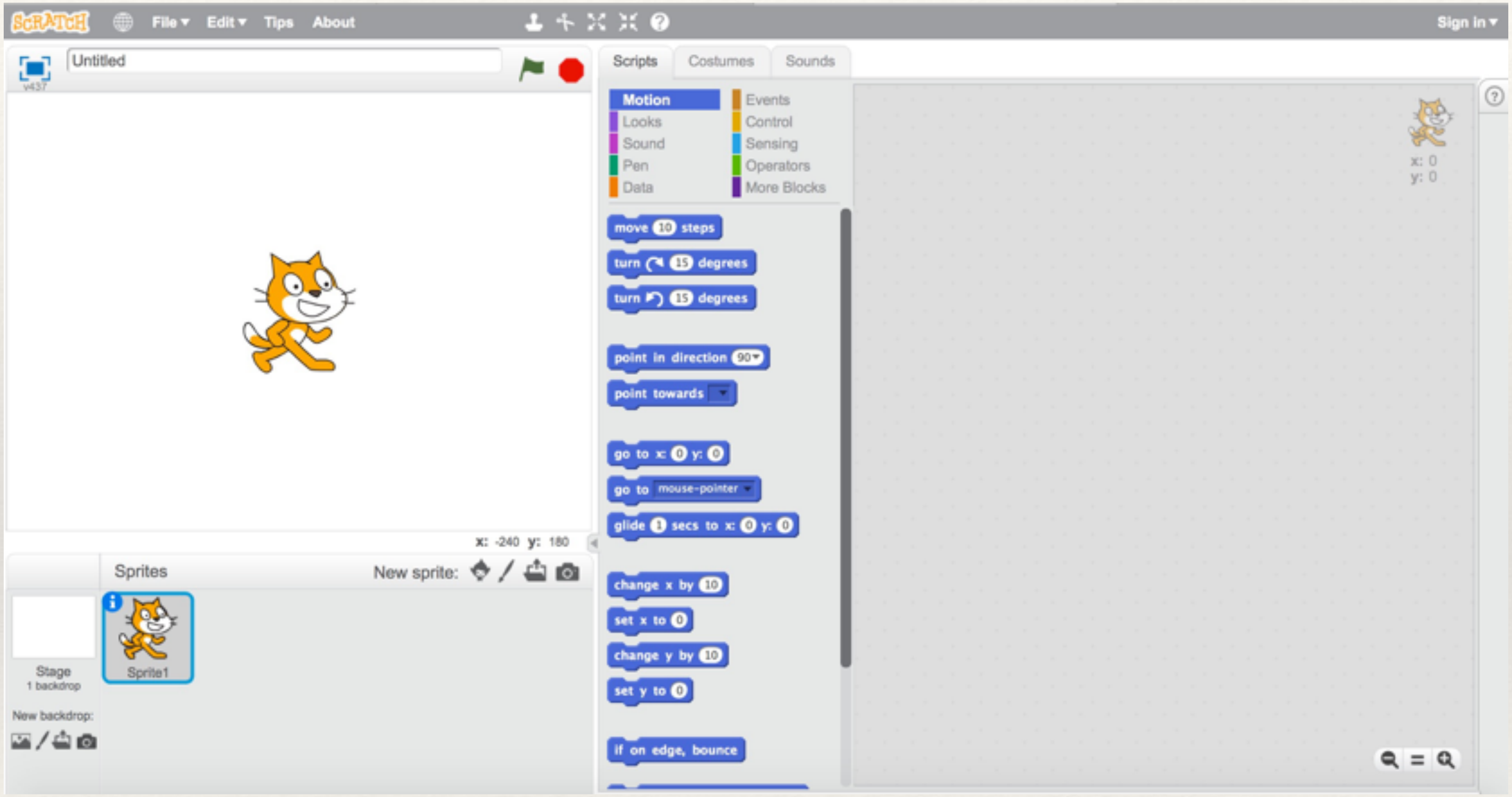




Welcor
To get

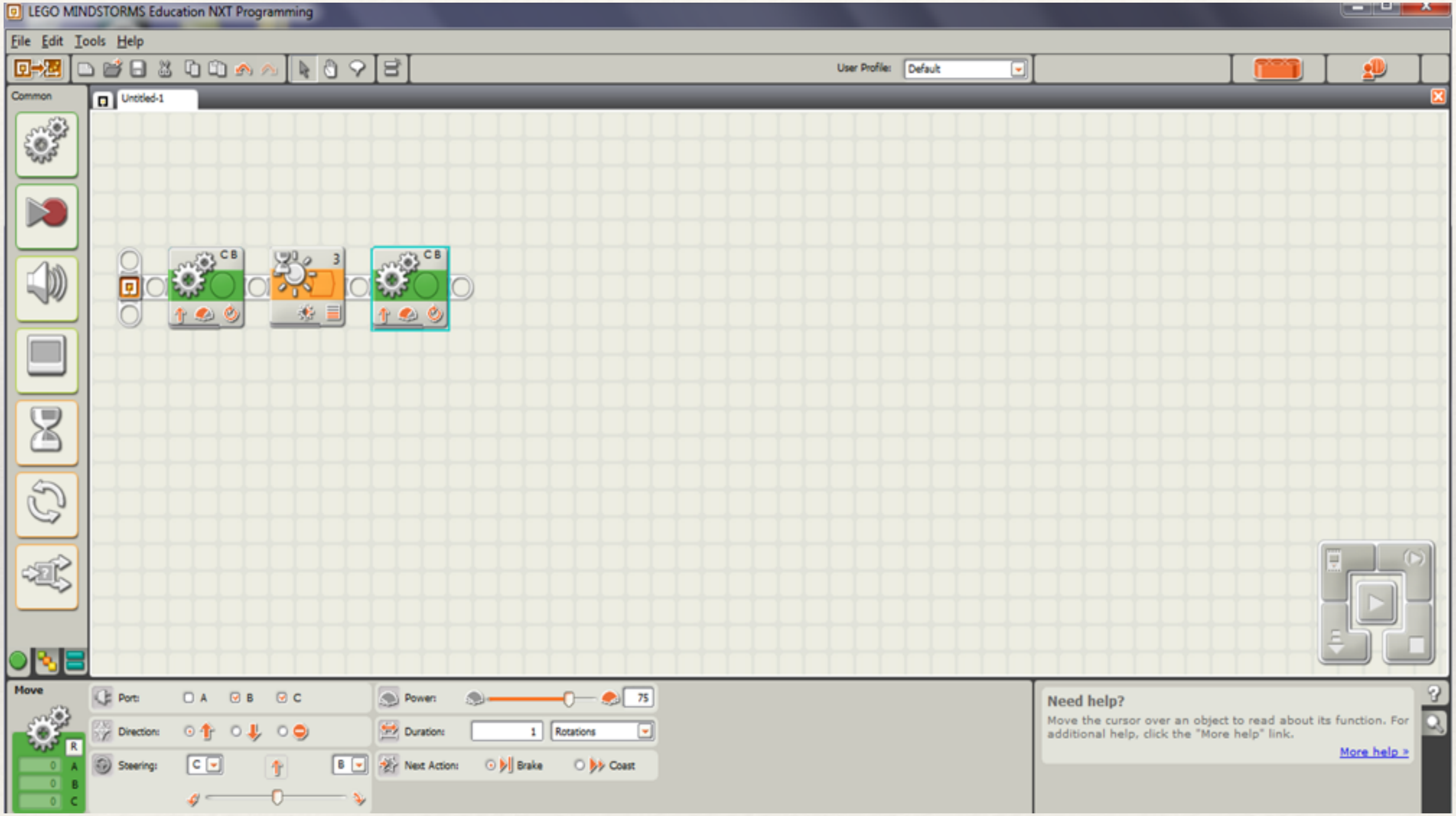
help at any time, see the Help Manual.

Scratch v2.0



Manual Creation	MynaMapper	Decrease in Time
600 minutes	41 minutes	93%

Lego Mindstorms NXT



Port: □ A ☑ B ☑ C

Direction: ● ↑ ○ ↓ ○ ⊖

Steering: C B

Power: 75

Duration: 1 Rotations

Next Action: ● Brake ○ Coast

Need help?

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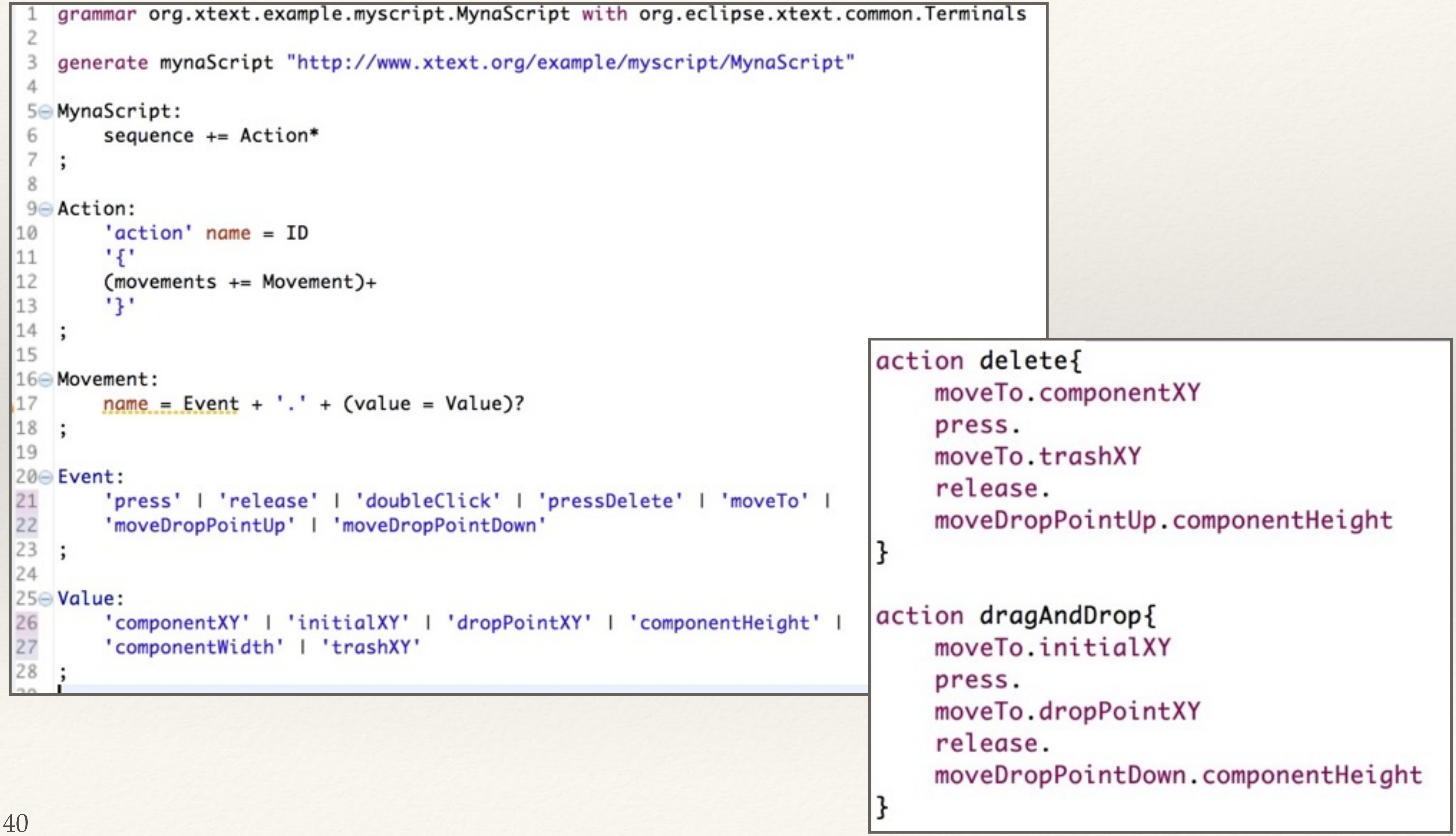
More help »

Manual Creation	MynaMapper	Decrease in Time
900 minutes	15 minutes	98%

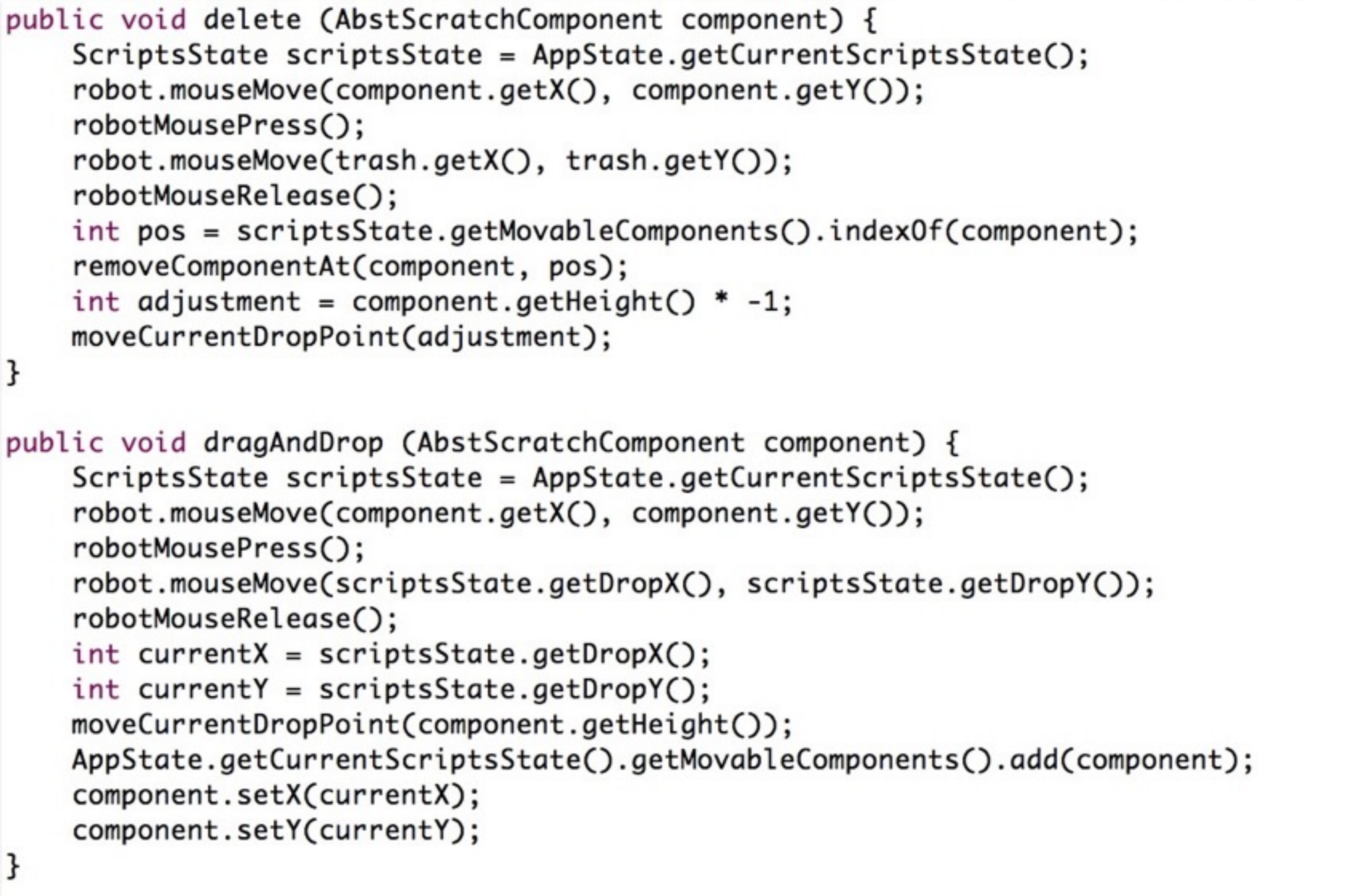
MynaScript



```
grammar org.xtext.example.myscript.MynaScript with org.eclipse.xtext.common.Terminals

generate mynaScript "http://www.xtext.org/example/myscript/MynaScript"

MynaScript:
	sequence += Action*
;

Action:
	'action' name = ID
	'{'
	(movements += Movement)+
	'}'
;

Movement:
	name = Event + '.' + (value = Value)?
;

Event:
	'press' | 'release' | 'doubleClick' | 'pressDelete' | 'moveTo' |
	'moveDropPointUp' | 'moveDropPointDown'
;

Value:
	'componentXY' | 'initialXY' | 'dropPointXY' | 'componentHeight' |
	'componentWidth' | 'trashXY'
;
```

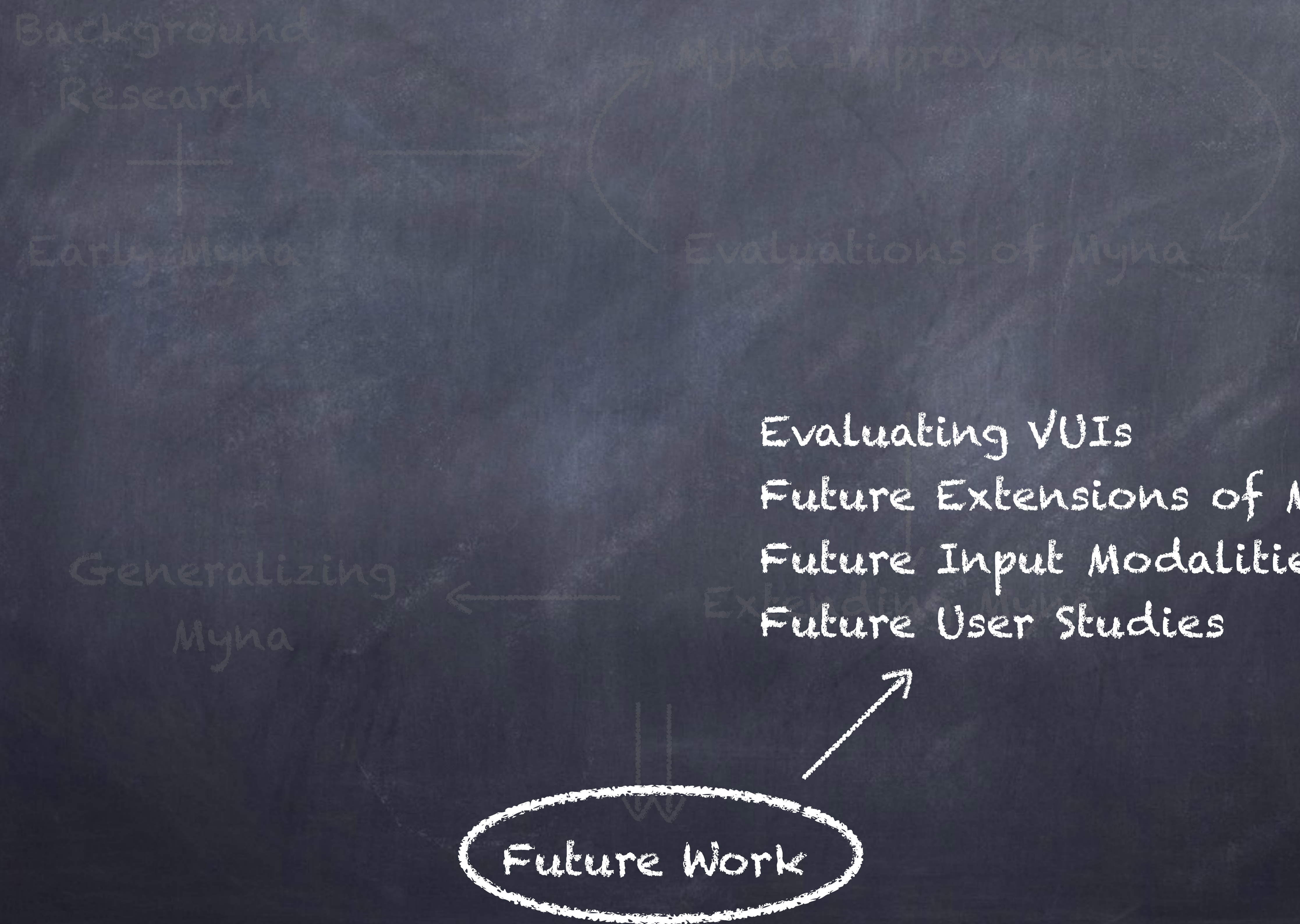
```
action delete{
	moveTo.componentXY
	press.
	moveTo.trashXY
	release.
	moveDropPointUp.componentHeight
}

action dragAndDrop{
	moveTo.initialXY
	press.
	moveTo.dropPointXY
	release.
	moveDropPointDown.componentHeight
}
```

Code Generation



```
public void delete (AbstScratchComponent component) {
    ScriptsState scriptsState = AppState.getCurrentScriptsState();
    robot.mouseMove(component.getX(), component.getY());
    robotMousePress();
    robot.mouseMove(trash.getX(), trash.getY());
    robotMouseRelease();
    int pos = scriptsState.getMovableComponents().indexOf(component);
    removeComponentAt(component, pos);
    int adjustment = component.getHeight() * -1;
    moveCurrentDropPoint(adjustment);
}

public void dragAndDrop (AbstScratchComponent component) {
    ScriptsState scriptsState = AppState.getCurrentScriptsState();
    robot.mouseMove(component.getX(), component.getY());
    robotMousePress();
    robot.mouseMove(scriptsState.getDropX(), scriptsState.getDropY());
    robotMouseRelease();
    int currentX = scriptsState.getDropX();
    int currentY = scriptsState.getDropY();
    moveCurrentDropPoint(component.getHeight());
    AppState.getCurrentScriptsState().getMovableComponents().add(component);
    component.setX(currentX);
    component.setY(currentY);
}
```

Dissertation Roadmap



Background Research

+

Early Myna

Myna Improvements

Evaluations of Myna

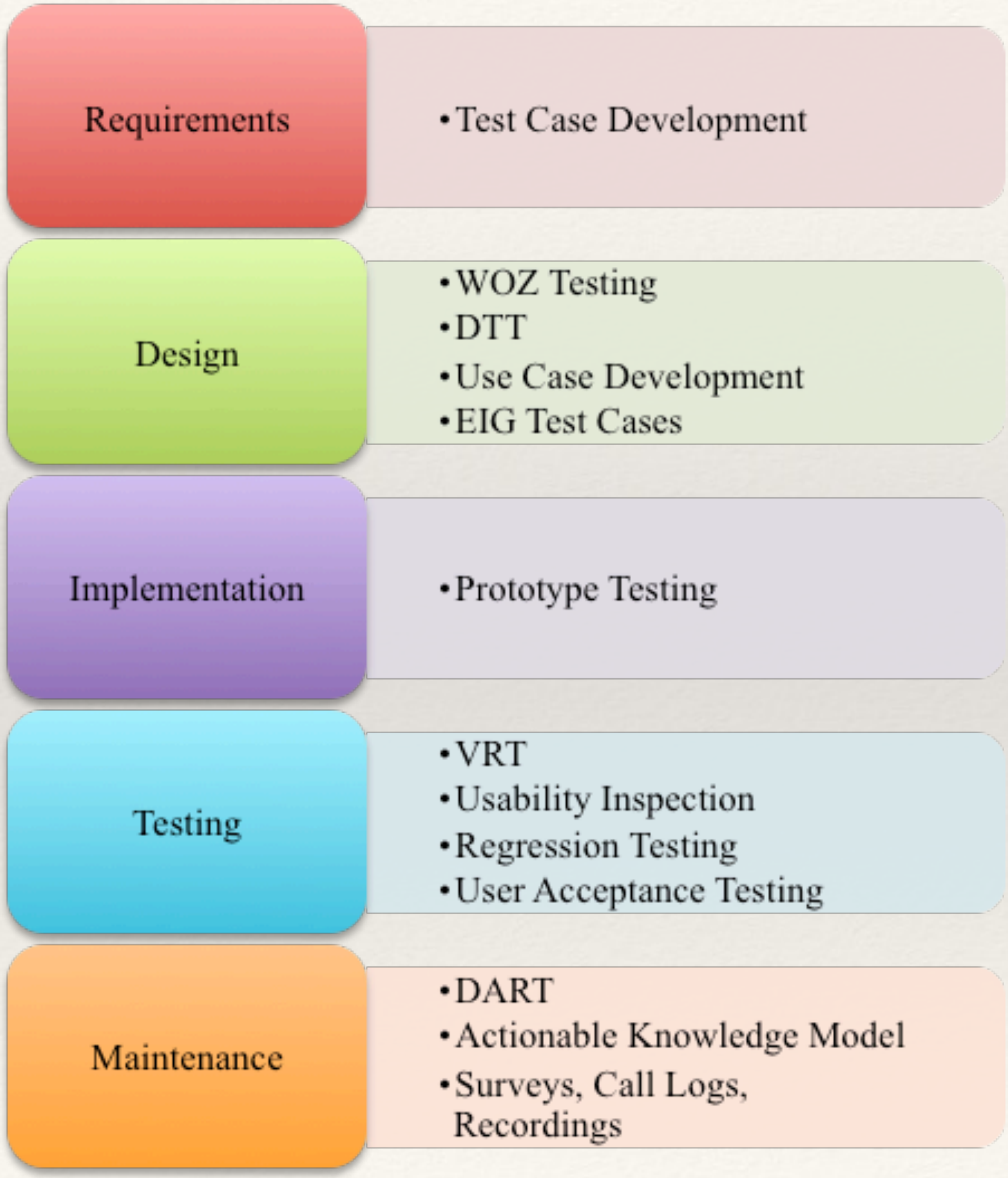
Extending Myna

Generalizing Myna

Future Work

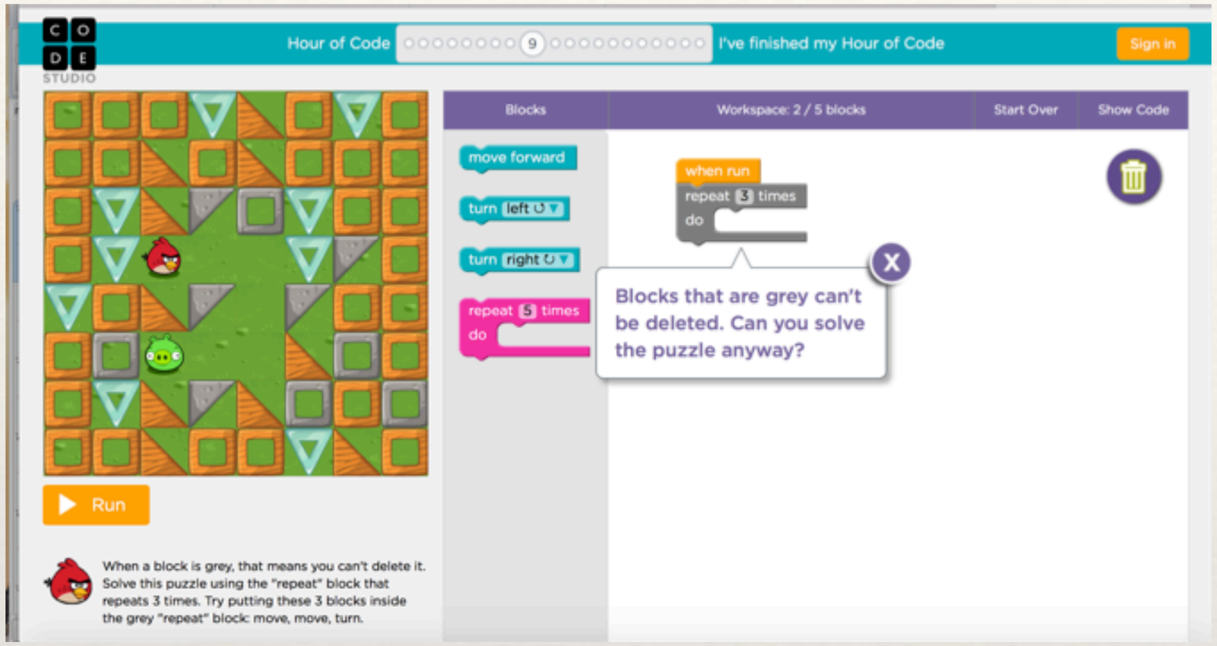
- Evaluating VUIs
- Future Extensions of Myna
- Future Input Modalities
- Future User Studies

Evaluating VUIs



- Requirements
  - Test Case Development
- Design
  - WOZ Testing
  - DTT
  - Use Case Development
  - EIG Test Cases
- Implementation
  - Prototype Testing
- Testing
  - VRT
  - Usability Inspection
  - Regression Testing
  - User Acceptance Testing
- Maintenance
  - DART
  - Actionable Knowledge Model
  - Surveys, Call Logs, Recordings

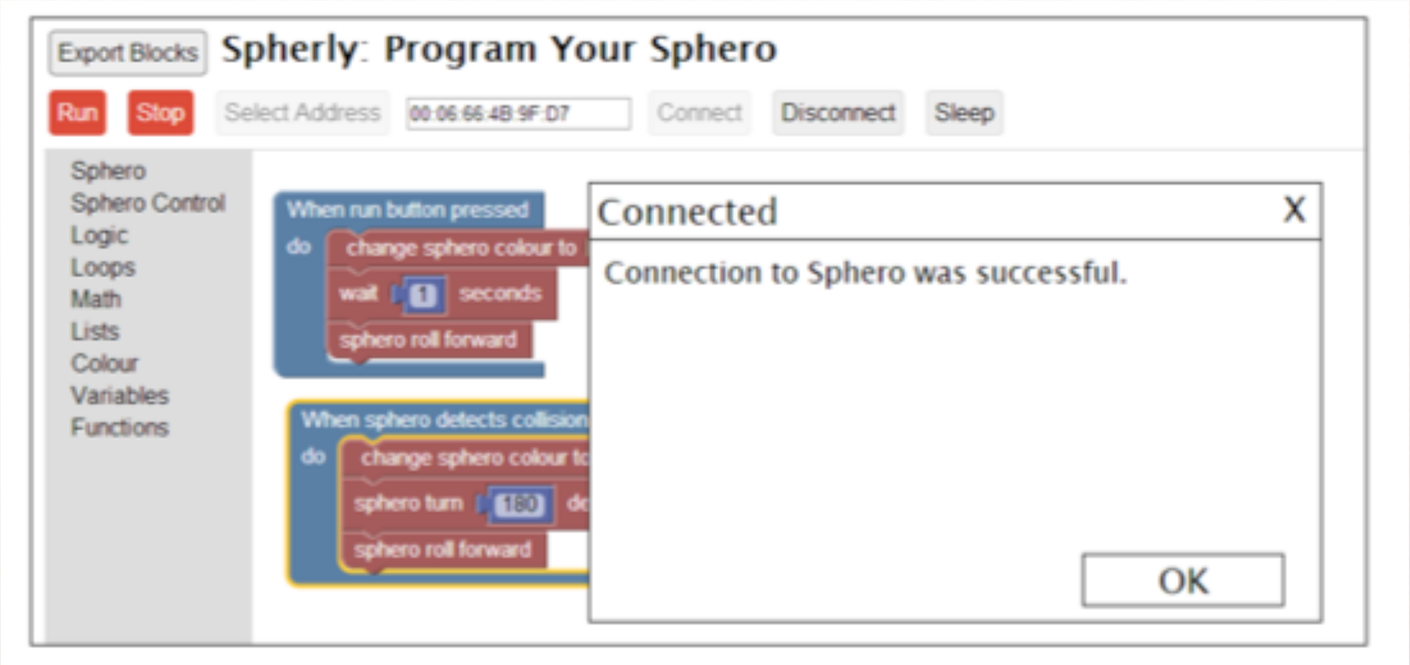
Future Extensions of Myna



```
when run
repeat 3 times
do
```

Blocks that are grey can't be deleted. Can you solve the puzzle anyway?

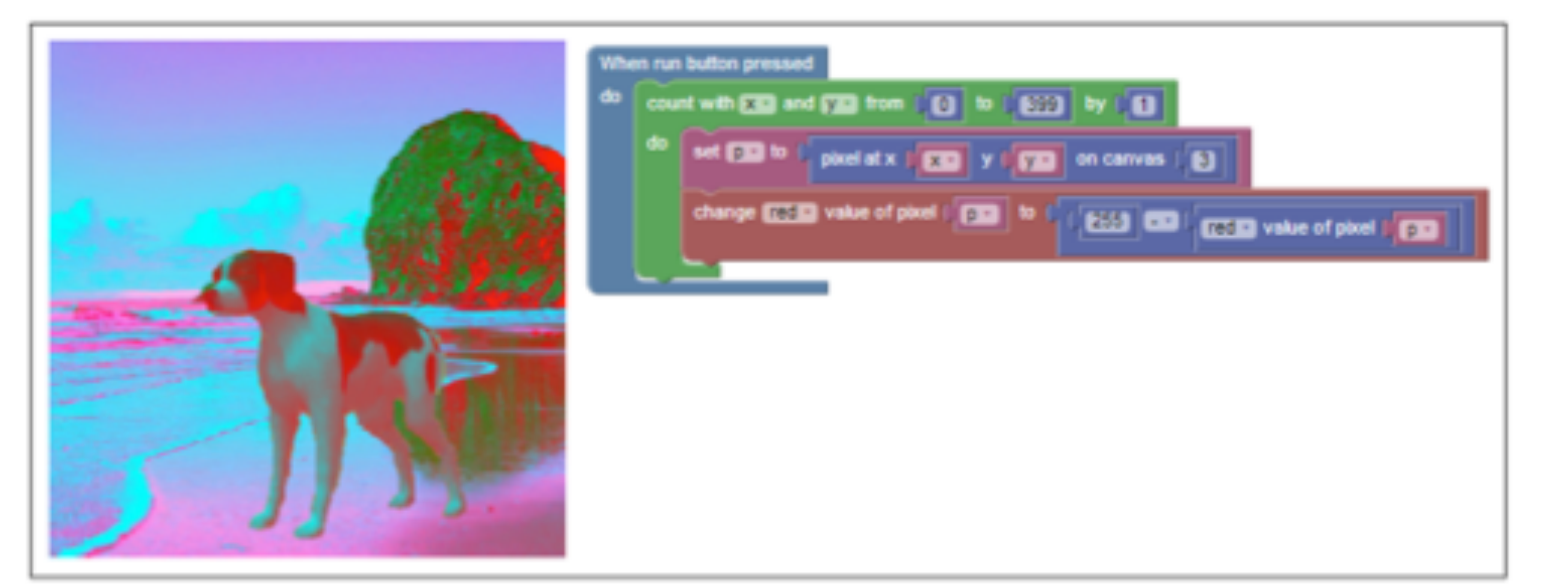
When a block is grey, that means you can't delete it. Solve this puzzle using the "repeat" block that repeats 3 times. Try putting these 3 blocks inside the grey "repeat" block: move, move, turn.



```
When run button pressed
do  change sphero colour to
    wait 1 seconds
    sphero roll forward

When sphero detects collision
do  change sphero colour to
    sphero turn 180 de
    sphero roll forward
```

Connected X

Connection to Sphero was successful.



```
When run button pressed
do  count with x and y from 0 to 399 by 1
    do  set p to pixel at x x y y on canvas 3
        change red value of pixel p to 255 - red value of pixel p
```

Future Input Modalities

Multimodal Input

Future User Studies

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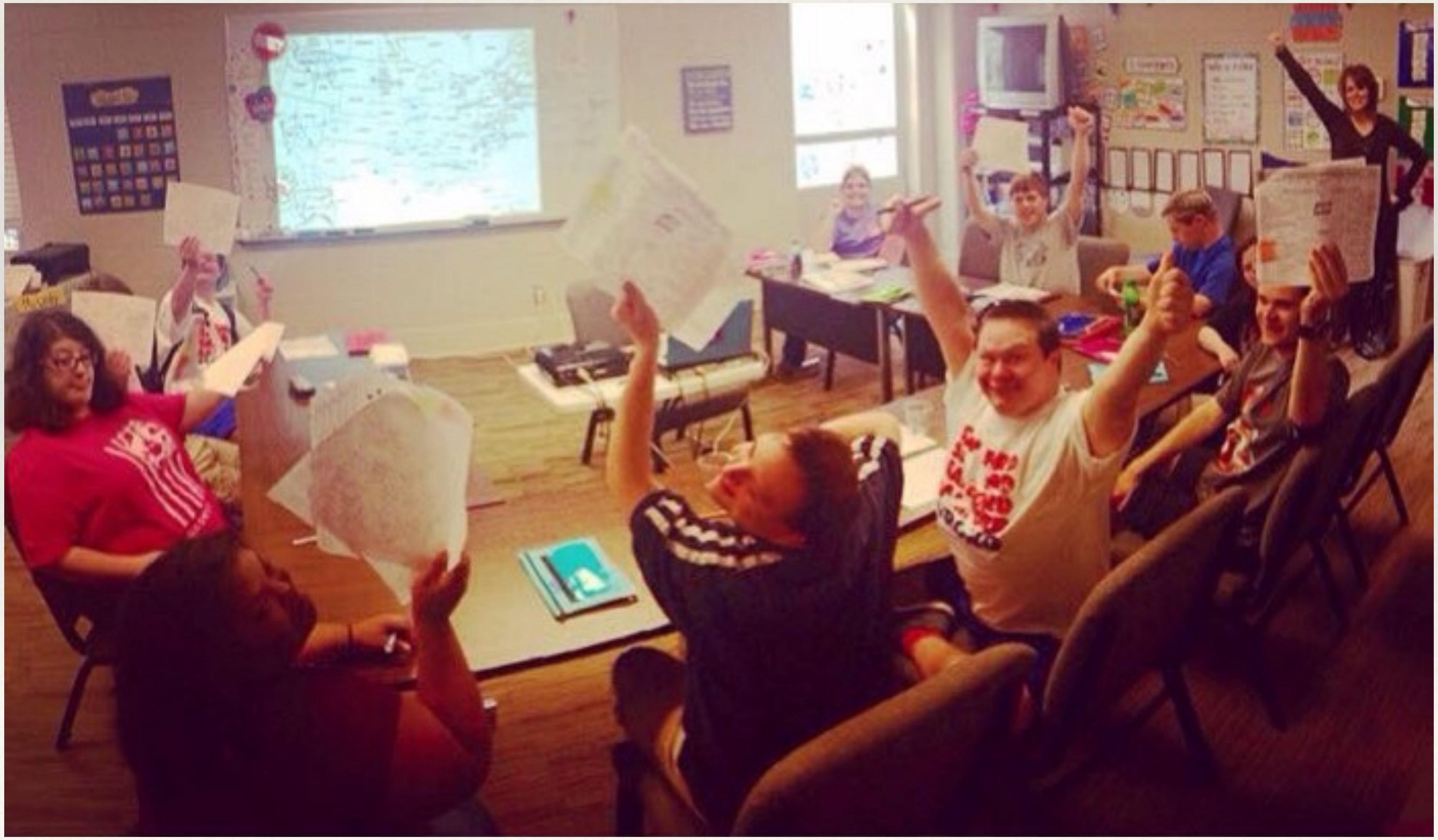
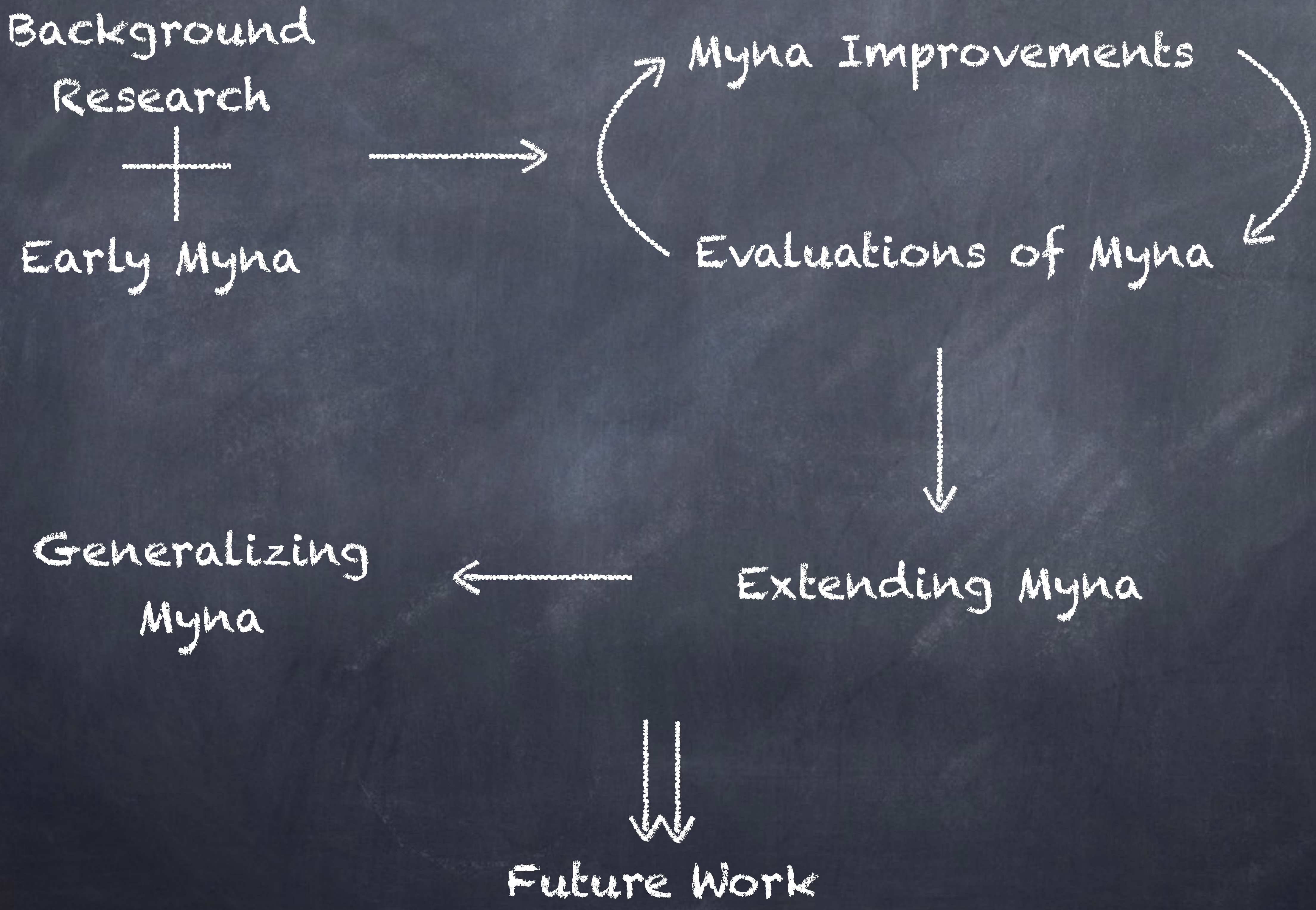


Conclusion



Background Research + Early Myna

Myna Improvements

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Future Work