

UNIVERSITY of WISCONSIN-MADISON
Computer Sciences Department

CS 202
Introduction to Computation

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How can computation... access data?

For data to solve problems, what do we need to do?

Capture

- Collect or obtain

Store

- Where? what if it gets lost?

Share

- Who should have access? Anonymize for privacy

Organize

- Sort it? put in categories?

Process it

- Search through it, analyze it, mine it for correlations

Visualize it

- What is useful for humans to look at?

Use results to inform our decision

Lists

Lists are common data structure

- List of items to buy at grocery store
- List of high scores for game
- List of student names in class (+email, id, grades)
- List of account balances at bank (+ account id)
- List of questions to ask in trivia game (+ answers)

Many items in List

Name the List as a whole

- Index into List to access individual items, elements
- Individual elements are named by their number (or index) in the list

Shopping Demo



Example List in Scratch

- Name: Valuable Numbers
- List of N elements: Element1, Element2, ..., ElementN
 - Don't need to know the size of N ahead of time
 - N can change...
- N=100 for Valuable Numbers
 - What value is at index 1? index 10?
 - At what location (or index) is value 73?



Lists in Scratch: How to Create?

Creates a new list that all sprites can see (such as scoreboard) or a new list that only this sprite can see (such as MyPhrases).

Once you make a list, eight blocks appear:

- list**: Reports all values of list. Click checkbox to show on stage.
- add [] to list**: Adds an item to the end of a list.
- delete [] of list**: Deletes an item from a list.
- insert [] at [] of list**: Inserts an item at specific place in a list.
- replace item [] of list with []**: Replaces an item in a list.
- item [] of list**: Reports the value of an item.
- length of list**: Reports number of items in a list.
- list contains []**: Reports whether that item is in the list.

Lists: How to Look at Contents?

Code blocks: `say Here is what you have! for 2 secs`, `say "Here's what you have:" for 2 seconds`, `say your list for 5 secs`, `say all the items in the list for 5 seconds`, `map keys lamp`.

Click the checkbox (next to the block) to show the monitor on the stage:

your list

Index	Value
1	map
2	keys
3	lamp

length: 3

The **list** block reports all the items in a list.
For individual items, use this block: **item [] of list**

Lists: How to Change the Contents?

Code blocks: `add [] to list name`, `add rock to my list`, `add paper to my list`, `add scissors to my list`, `say item any of my list for 2 secs`.

Index	Value
1	rock
2	paper
3	scissors

length: 3

Use this block if you want to add an item to the end of a list:
`add your words or number here to your list`

Can't find the list blocks? You need to first to make a list: `Make a list`

Lists: How to Change the Contents?

insert thing at [] of list []

when the lamp sprite is clicked
insert lamp at 1 of my list insert the item "lamp" at the first place in the list

Before:

my list	
1	compass
length: 1	

After:

my list	
1	lamp
2	compass
length: 2	

You can indicate where in the list you want to add an item.

insert score at 2 of scoreboard inserts item at the specified place in the list

insert Hello, world at any of greetings inserts item at a random place in the list

Lists: How to Change the Contents?

replace item [] of list [] with []

replace item 1 of scoreboard with score replaces item 1 in the list with the current score

Before:

scoreboard	
1	3
2	8
length: 2	

After:

scoreboard	
1	10
2	8
length: 2	

You can choose where in a list to put an item. For example:

replace item 2 of race times with timer replaces item 2 in the list

replace item last of questions with How are you? replaces last item in the list

Lists: How to Remove Items?

delete [] of list []

say item 1 of supplies for 2 secs says the first item from the list
delete 1 of supplies deletes the first item in the list

Before:

supplies	
1	water
2	piece of fruit
3	biscuits
length: 3	

After:

supplies	
1	piece of fruit
2	biscuits
length: 2	

Lists: How to Remove Items?

You can specify the number of the item you want to delete. For example:

delete 2 of my list deletes item 2 from the list

To delete the last item in the list, choose "last" from the pull-down menu:

delete last of my list

You can also choose to delete everything in the list:

delete all of my list

Lists: How to Look at the Contents?



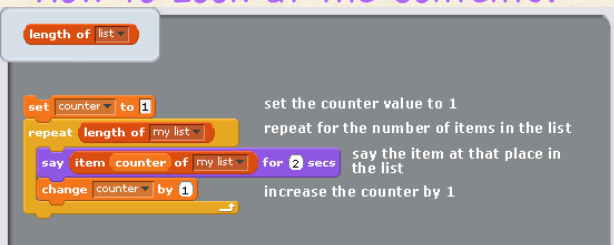
The image shows three Scratch code blocks:

- item 1 of list:** A block with a dropdown menu for 'list' and a text input for '1'.
- say item any of phrases for 2 secs:** A block with a dropdown for 'phrases', a dropdown for 'any', and a text input for '2'.
- if score > item 1 of top scores:** An 'if' block with a dropdown for 'top scores' and a dropdown for '1'.

The item block reports the value of the item at the specified place on a list.

You can fit an item block into other blocks, for example: say, switch to costume, play sound, or broadcast.

Lists: How to Look at the Contents?



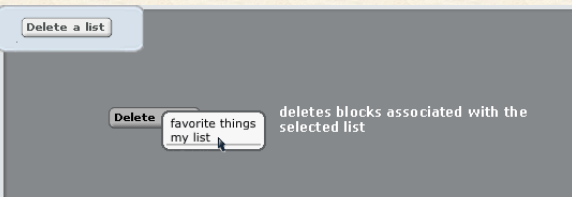
The image shows three Scratch code blocks:

- length of list:** A block with a dropdown menu for 'list'.
- set counter to 1:** A block with a text input for '1'.
- repeat length of my list:** A 'repeat' block with a dropdown for 'my list' and a dropdown for 'length of'.

This block reports how many items are currently in a list.

The number is the same as the length shown at the bottom of the list monitor.

Lists: How to Delete Entire List?



The image shows a 'Delete a list' block with a dropdown menu for 'list' and a text input for 'favorite things my list'.

Note: When a list is deleted, any of its blocks used in scripts will remain, but the scripts will not function properly.

1) Make a List called "Names"

Insert 10 names into a list called "Names"

- Could modify list by hand...
- Better to write a script "Make Names" that does this
- Make sure it behaves correctly if run multiple times!

2) Say All Names

Make a script named "Say All Names"

- Sprite should "say" each item in Name List one at a time (in order!)
- Side note: Sprite can "say" entire Name List at once
- Challenge: Script should work for any list called Name (of any length, not just 10!)
- Hint: Need a new variable "index"

3) Make a List called Ages

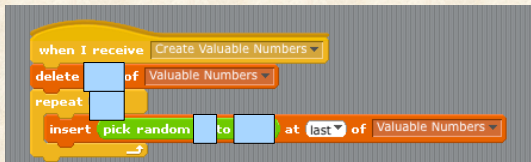
Make a script called "Make Ages"

- Insert 10 ages into the list
- All ages should be randomly generated between 17 and 23

How to Make List with 100 Random Numbers?

New script: Create Valuable Numbers

- Puts result in List: Valuable Numbers
 - Contains 100 elements
 - Each element: Integer between 1 and 1000



4) Does Age List contain 20?

Check to see if list contains the age "20"

- Hint: Can do this with one instruction!

5) Where does Age 20 Appear?

Where in list does age appear?????
 What name corresponds to that age?

"Search" has many meanings

- Look up "name" in phonebook (get number)
- Find "credit-worthy" consumers in database
- Find web pages relevant to "computer music"
- Identify suspicious cell phone conversations originating in Country X
- Find the meaning of life

- Today: Very straight-forward
 - Find specified KEY in a LIST
 - Find maximum element in a LIST

How can you find value in list?

Index	Value
1	689
2	42
3	575
4	823
5	33
6	563
7	320
8	591
9	93
10	639
11	132
12	73
13	859
14	149
15	197

What does it mean to "find" value? (e.g. 93?)

Know "index" (or location) of value in list
 (index = 9)

What algorithm would you use?

- Look at each item of list
 - Is this value looking for? Yes?
 - Done! No?
 - Look at next element
- Repeat for all elements of list
- If reach end and don't find?
 - Item not in list

Robust to length of List

- Should work for list of any length

5) Where does Age 20 Appear?

Where in list does age appear?????

- Use Variable "Key" to hold age you are searching for (i.e., set Key to 20)
- Use Variable "Key Index" to hold answer (location of key)

How to implement search?

- Look at each item of list
 - Is this value looking for?
 - Yes, done!
 - No, look at next element
- Repeat for all in list
- If reach end and don't find?
 - Item not in list
- Robust to any length

Variables?

List of Valuable Numbers (input)
 Key: Value searching for (input)
 Key Index: Answer (output)
 Index : Loop through List; tracks current location

```

when I receive Find Key
  set index to 1
  set Key Index to 0
  repeat
    if item index of Valuable Numbers =
      set Key Index to
      stop script
    change index by 1
    
```

6) How to display matching Name?

Have corresponding Names list

Use Key Index to "index" into Name list

Take care to use broadcast and wait

- (and not just broadcast)
- Find Key script must finish to guarantee it has set value of "Key Index" variable

How do we know if Key not found?

- Key index is 0!

```

when clicked
  broadcast Create Valuable Numbers and wait
  ask What number should I search for? and wait
  set Key to answer
  broadcast Find Key and wait
  if not Key Index = 0
    say join join The key Key join is located at index Key Index for 2 secs
    say join The matching name is item Key Index of Names
  else
    say join join The key Key was not found!

when I receive Find Key
  set index to 1
  set Key Index to 0
  repeat length of Valuable Numbers
    if item index of Valuable Numbers = Key
      set Key Index to index
      stop script
    change index by 1
    
```

Check-Up

How many items can you put in a list?

How do you find the number of items in a list? `length of Random Numbers`

What is the difference:

```

add 100 to Random Numbers
insert 100 at 1 of Random Numbers
    
```

What is the difference:

```

delete all of Random Numbers
Delete a list
    
```

For the given list, what would this code do?

```

if Random Numbers contains 149
  play sound Bird until done
else
  play sound Cricket until done
    
```

Valuable Numbers	
1	689
2	42
3	575
4	823
5	33
6	563
7	320
8	591
9	93
10	639
11	132
12	73
13	859
14	149
15	197
+ length: 100	

What will these scripts do?

Stage scripts

```

when clicked
  broadcast start
  clear

when I receive start
  delete all of Pen Color
  delete all of Pen Shade
  repeat 10
    add pick random 1 to 100 to Pen Color
    add pick random 1 to 100 to Pen Shade
  broadcast ok
    
```

Initializes two lists:
Pen Color and Pen Shade

How long is each List?

2: What will these scripts do?

```

when I receive ok
  hide
  pen up
  go to x: 0 y: 0
  set pen size to 3
  set y to 0
  repeat until y > 171
    set x to 0
    repeat until x > 231
      set c to pick random 1 to 10
      broadcast draw and wait
      change x by 10
    change y by 10
  broadcast start

when I receive draw
  pen up
  set pen color to item c of Pen Color
  set pen shade to item c of Pen Shade
  go to x: x y: y
  pen down
  pen up
  go to x: -1 * x y: y
  pen down
  pen up
  go to x: x y: -1 * y
  pen down
  pen up
  go to x: -1 * x y: -1 * y
  pen down
  pen up
    
```

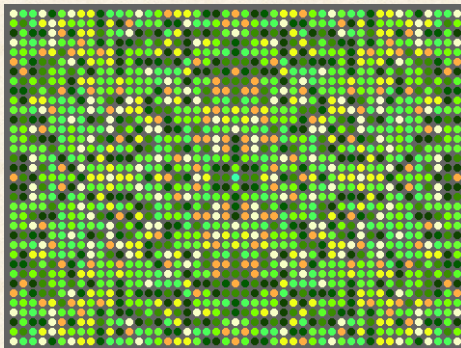
How are x, y varied?

How many pen points for each x,y?

What is relationship of two Lists?

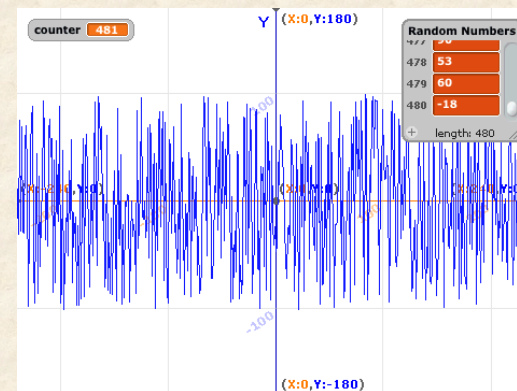
What is purpose of c?

Result of Running Scripts



Symmetric picture along both x and y axis (4 quarters)
Ten different color/shade combinations

Plot Values in List



How can you find Max value in list?

How is this different than finding specified key?

- Don't know max value before start

How do you know found maximum?

- Greater than (or equal to) all others in list

Approach to finding maximum?

- Remember the largest seen so far
- If current key > current max, remember current key as new max

Valuable Numbers	
1	689
2	42
3	575
4	823
5	33
6	563
7	320
8	591
9	93
10	639
11	132
12	73
13	859
14	149
15	197
length: 100	

Similar Code Structure

Find Key

```

when I receive Find Key
  set index to 1
  set Key Index to 0
  repeat length of Valuable Numbers
    if item index of Valuable Numbers = Key
      set Key Index to index
      stop script
  change index by 1
  
```

Find Max

```

when I receive Find Max
  set Max to 0
  set index to 1
  set Max Index to 0
  repeat length of Valuable Numbers
    if item index of Valuable Numbers > Max
      set Max to item index of Valuable Numbers
      set Max Index to index
  change index by 1
  
```

Similarities?

Loop through List using "index" which starts at 1, increments by 1, thru length
Key Index or Max Index set to index where element is located

Differences?

Find Max: Uses Max to record current max (initialize to 0...)

Find Max: Must look through every element of list (don't stop early)

Linear Search

Summary: Examine all of the elements of list looking for a match; examine elements in order

Inefficient algorithm; why?

Efficiency (performance) really matters when millions or billions of elements!

How efficient is an algorithm?

Option 1: Could run and measure how it takes

- Disadvantage: Depends on hardware
- Disadvantage: Don't know efficiency on different lists

Option 2: Can analyze code

- Count number of operations performed
- Advantage: Understand how behavior depends upon size of input
- Use N for number of elements in input (List)

How many operations to find max?

Count number of Scratch blocks

Which blocks to count?
Exclude reading variables

```

when I receive Find Max
  set Max to 0
  set index to 1
  set Max index to 0
  repeat length of Valuable Numbers
    if item index of Valuable Numbers > Max
      set Max to item index of Valuable Numbers
      set Max index to index
    change index by 1
  
```

How many blocks?

How many before loop?

- 3 blocks to start up

How many in loop?

- Assume worst-case (take if = true)
- Approx 6...

How many times is loop executed????

- N

Total: 3+7*N blocks

- O(N) blocks
- # times loop executed, not # blocks in loop

Linear Search

Check-Up

```

when I receive Find Max
  set Max to 0
  set index to 1
  set Max index to 0
  repeat length of Valuable Numbers
    if item index of Valuable Numbers > Max
      set Max to item index of Valuable Numbers
      set Max index to index
    change index by 1
  
```

What assumption does script make?

- Values in list > 0

How to implement "Find Min"?

- What to set Min to?
- Item 1 of Valuable Numbers

Challenge Check-Up

What does this script do?

```

when I receive Create Valuable Numbers
  delete all of Valuable Numbers
  delete all of Names
  repeat 100
    add pick random 1 to 1000 to Valuable Numbers
    set One Name to 1
    repeat 5
      set One Name to join letter pick random 1 to 26 of abcdefghijklmnopqrstuvwxyz length: 100
    add One Name to Names
  
```

Names	
1	qppap
2	ultnu
3	rmeto
4	zpkdz
5	vpfsk
6	rrdwr
7	wvmzw
8	ixwtz
9	yubki
10	lbeod
11	swvli
12	qfrss
13	azxer
14	ekauu
15	khnxp

Output:

- List: Valuable Numbers (100 elements)
- List: Names
 - 100 elements, each element is a 5 letter random string