Engaging Students in Active Learning of Computer Science Concepts

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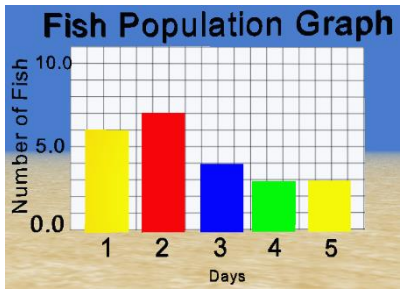
Duke University

Feb. 7, 2015
ACM–iSIGCSE Workshop
Goa, India



Supported by NSF Grants DRL-1031351, DUE 1044191, CRA, and IBM Faculty Awards

Thanks for inviting me!

- Tell you about SIGCSE from my experiences
- Then – Engaging Students in Active Learning of CS Concepts

Professor of the Practice
Duke University
Computer Science Department

- What does that mean?
- Focus on Education in the discipline
- Assistant, Associate, Professor
- 20% of Arts and Science faculty
- Also use position in other ways
  - Hire journalist – Washington Post
  - Industry Liaison

Back in 1989

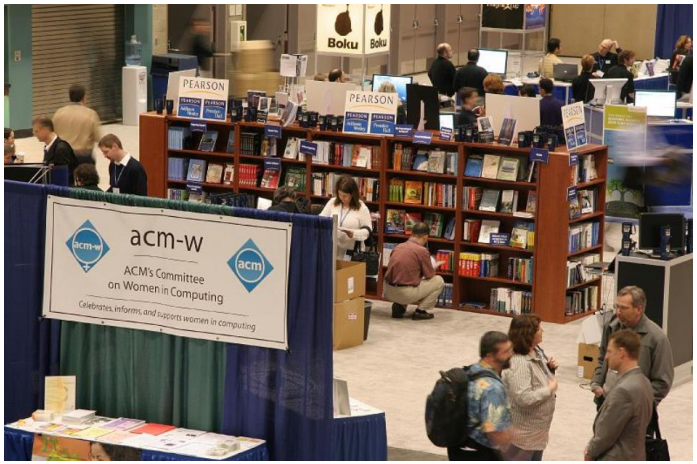
- PhD at Purdue University

- Assistant Professor at Rensselaer Polytechnic Institute

- First Task – combine first two computer science courses with automata theory

SIGCSE

- 1990 – interested in CS Education
- 1992 – my first SIGCSE conference
- 1996 – my first ITiCSE conference
- 2006 – my first ICER workshop
- 2015 – my first ACM India conference!
- 2015 – my first iSIGCSE event!

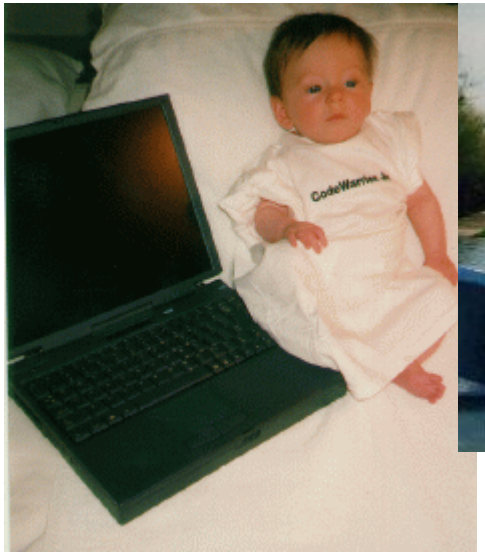


Never missed a SIGCSE Symposium since I started going

- 1997

First son

2000



Second son

Brought help

What SIGCSE has meant to me

- Great colleagues
  - Friendliest people
  - Friendliest conferences
- Learn about innovative pedagogy
  - Use in my courses
- Share
  - My ideas
  - My curriculum materials and software

Examples of Panels at SIGCSE Symposium

- 90's – AP Computer Science transition from Pascal to C++
- Mid - 90's – AP CS transition from C++ to Java
- What to teach in the first course
- Policies for getting computing into K-12
- ACM Curriculum

Special Session – Nifty Assignments nifty.Stanford.edu

- Example: Evil Hangman
- First do a hangman assignment
  - Randomly select a word
  - Guess letters until spelled word
  - Only get so many tries

```
# letters in word:  8
# guesses to hanging:  7

_ _ _ _ _ _ _ _
misses left:  7
guesses so far:
guess letter:  e
no e

_ _ _ _ _ _ _ _
misses left:  6
guesses so far:  e
guess letter:  a
no a

_ _ _ _ _ _ _ _
misses left:  5
guesses so far:  a e
guess letter:  o
no o

_ _ _ _ _ _ _ _
misses left:  4
guesses so far:  a e o
guess letter:  u
no u

_ _ _ _ _ _ _ _
misses left:  3
guesses so far:  a u e o
guess letter:  i
_ _ _ i _ _ i _
misses left:  3
```

Evil Hangman

- Make it difficult to win
  - Keep changing the word after the user guesses
  - After each guess, create the largest set of words that could be the match
- Word is: truck
- User guesses: u
- Change secret word to a word without ‘u’

Game Output

```
(secret word: jumpy ) # words possible:  87
Progress:  _ _ _ _ _
letters missed:  a i s e o
guess a letter:  u
__u__ 32
_u___ 47
_____ 8
-------
you guessed a letter correctly!
(secret word: bulky ) # words possible:  47
Progress:  _ u _ _ _
letters missed:  a i s e o
guess a letter:  b
_u___ 33
bu___ 14
-------
b  not in secret word
(secret word: lucky ) # words possible:  33
Progress:  _ u _ _ _
letters missed:  a b e i o s
guess a letter:  c
cu___ 2
_uc__ 2
_u___ 21
_u_c_ 8
-------
c  not in secret word
(secret word: funny ) # words possible:  21
Progress:  _ u _ _ _
letters missed:  a c b e i o s
guess a letter:
```

Check out other Nifty Asssignments

Hope your SIGCSE grows and grows

- Expect to see an annual conference in India…
- Expect impact in both undergraduate curriculum and schools

Outline

- Lecture formats
- Prepare for Class
- Class participation
- Engaging with Software
- Peer-led team learning
- Engaging in other ways

Motivation

- Traditional way of teaching
  - Professor Lectures
  - What students hear about 87%

BLAH BLAH BLAH BLAH BLAH

Active Learning - Workshop Format "Flipped" Classroom

- Lecture for 10-20 minutes
- Students work on problem with computers in pairs
- Bring students back together
- Pair programming

Alternative

- Work in pairs
- Everyone has their own laptop

Groups/Pairs

- Assigned

```
CompSci 4 Section 1
Pairs as of October 22, 2009

   Front of room

         G1 G2  G3 G4
 G5  G6  G7   G8   G9
 G10 G11 G12 G13 G14 G15
 G16 G17 G18 G19 G20
 G21 G22 G23 G24 G25

Group 1
Starkweather,Clara cks15@duke.edu
Dinkins, Tiffany tiffany.dinkins@duke.edu

Group 2
Listenbee,Kamerria kkl7@duke.edu
Brown,Dwayne dcb26@duke.edu

Group 3
```

Outline

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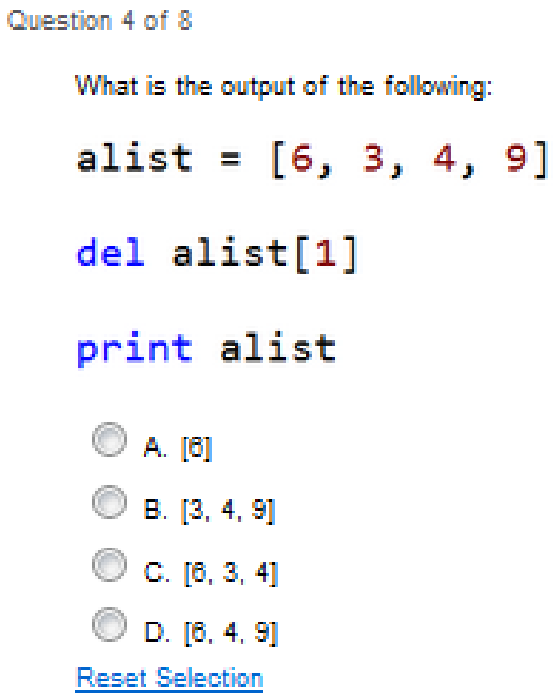
- Peer-led Team Learning
- Engaging in other ways

Read the book

- Read before coming to class
  - Ready to work in class
- Reality
  - Run out of time to read, not prepared
- Bring on – Reading quizzes
  - Online
  - Turn off when class starts



Have an engaging book….

- Runescape (Brad Miller)

Here is the program in activecode. Note that the function definition is the same as it was before. All that has changed is the details of how the squaring is done. This is a great example of "black box" design. We can change out the details inside of the box and still use the function exactly as we did before.

Run | Save | Load | Show in Codelens

```
1 def square(x):
2     runningtotal = 0
3     for counter in range(x):
4         runningtotal = runningtotal + x
5
6     return runningtotal
7
8 toSquare = 10
9 squareResult = square(toSquare)
10 print("The result of", toSquare, "squared is", squareResult)
11
```

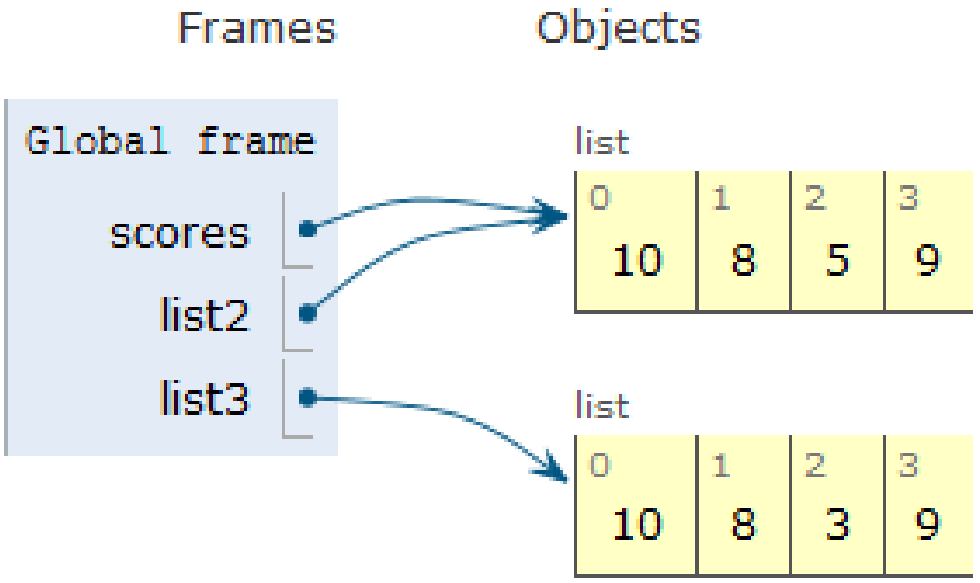
ActiveCode: 1 (sq_accum1)

Electronic Textbooks (ebooks) engage students

- OpenDSA (Shaffer, Virgina Tech)
  - Algorithm animations built in
- runestoneinteractive.org (Brad Miller,
  - Several books (Python)
    - Python - try and run code built in
    - Quizzes
- Zyante.com – interactive textbooks
- Track student progress
- Requirements and design strategies for open source interactive computer science eBooks
  - ITiCSE 2013 Working Group (Korhonen, Naps, et al)

Use engaging and visual tools Python Tutor

```
1  scores = [10, 8, 3, 9]
2  list2 = scores
3  list3 = scores[:]
4  scores[2]=5
```

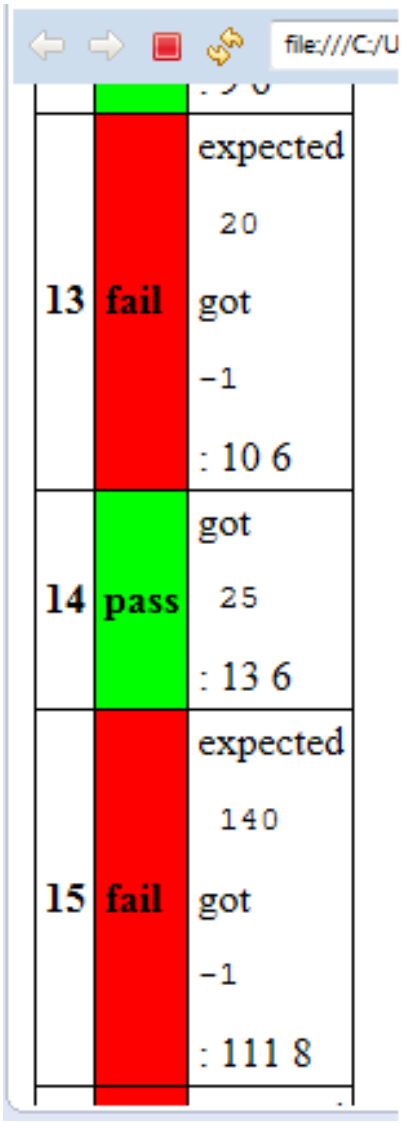


Problem Solving with Feedback

- APT – Algorithmic Problem Tester
- Test one function
- Runs on multiple inputs

# of correct: 14 out of 17

1	pass
2	pass
3	pass
4	pass
5	pass
6	pass
7	pass
8	pass
9	pass
10	pass
11	pass
12	pass
13	fail
14	pass



Outline

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- Engaging with Software
- Engaging in other ways

Ways to Select students to answer questions

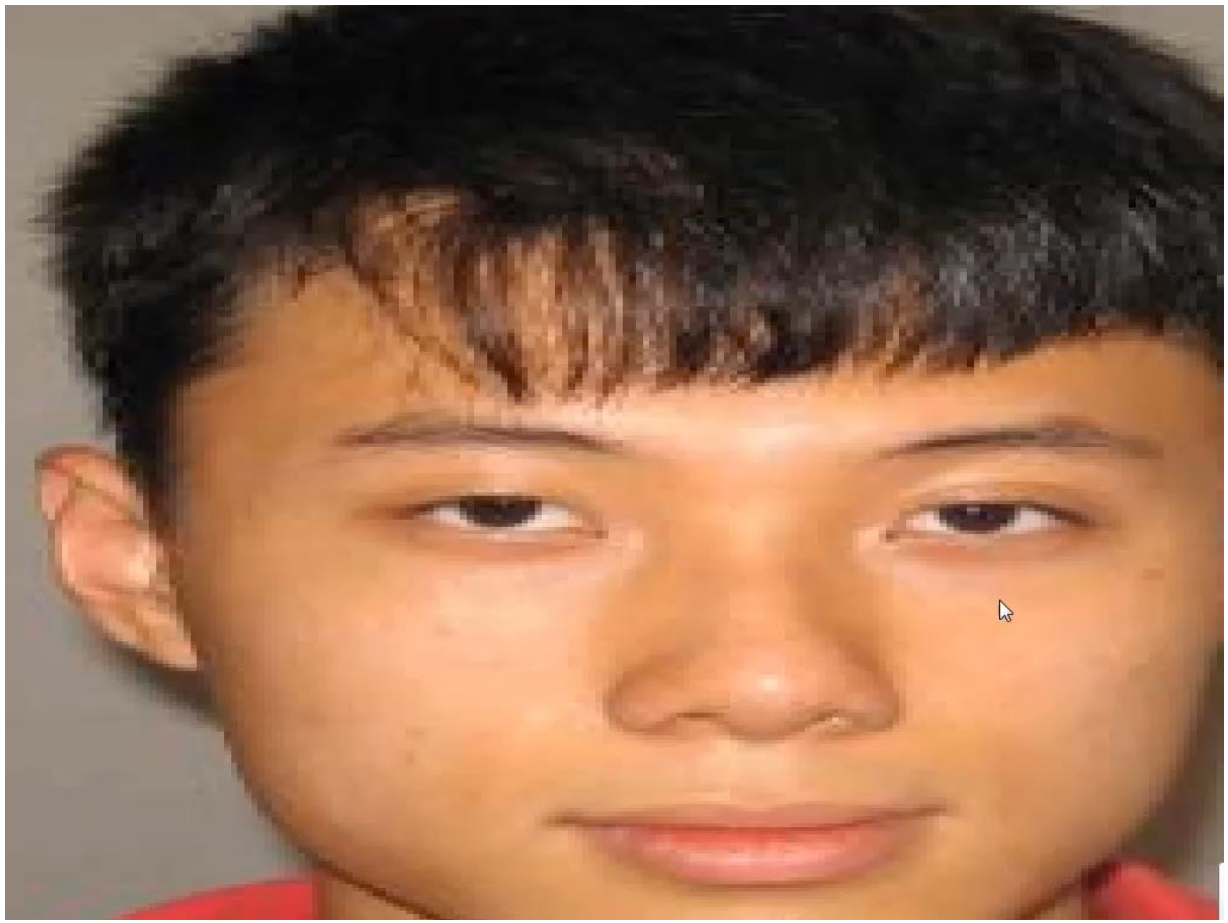
- Problem – same students always eager
- How do you get other students to participate?
  - Randomly call on them
  - Pick A Student program
  - Work in groups – call on group
  - Assigned groups – call on group numbers

Randomly Select a Student
Pick A Student Program

Collect pictures of students

program that cycles through and randomly picks one

Remove, then start again



From Owen Astrachan

Google Forms

Mystery While

* Required

NETID of person 1 *

Example: abc123

NETID of person 2

Example: abc123

NETID of person 3

Example: abc123

NETID of person 4

Example: abc123

Names of people filling out form *

(first and last name for each person, separate each name by a comman)

Google Forms (cont)

What does Mystery2 do (in words)?*

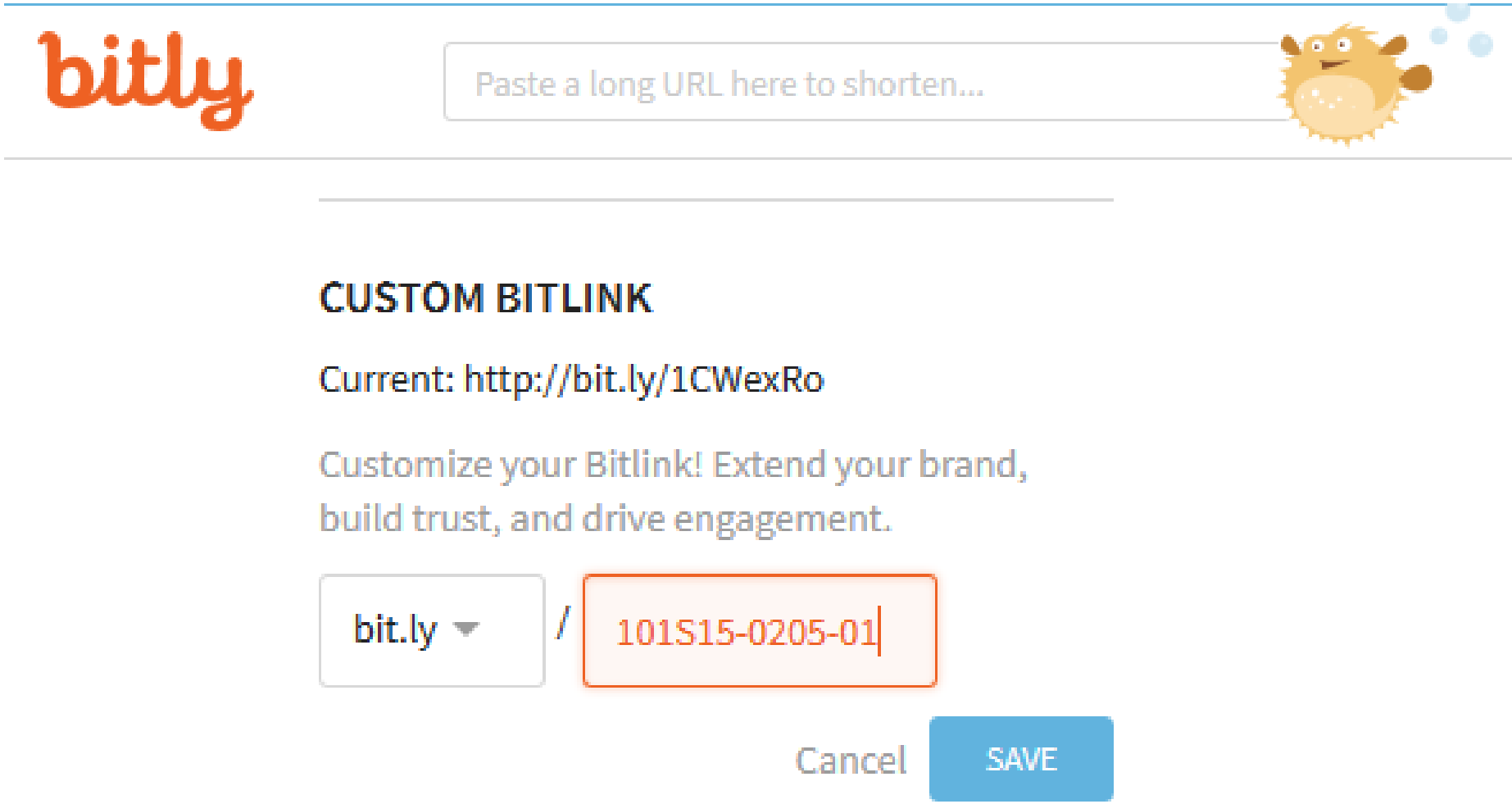
What does Mystery3 do?*
(in words)

Google Forms (responses)

H	I	J	K	L
What does Mystery3 do?				
It counts every character in a word except for lowercase "e"s				
It counts the number of characters in the word that aren't lowercase e's.				
It is counting the number of characters in the word that are not e's				
Count the number of characters that are not 'e' in the word				
Mystery 3 retums a given a given word without the lowercase e's.				
Counts the lower case es in the word.				
It retums the number of characters in a word that are not e.				
Counts all of the letters in word that aren't 'e'				
Counts the number of characters that are not e in the word.				
Counts all the characters that aren't e				
counts how many letters there are that are not "e"				
Mystery 3 counts the characters in a string that are not 'e', then returns the total count.				

Setting up Google Forms

- Make it easy for students to get form



Outline

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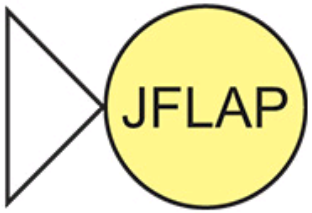
- Class participation
- Engaging with Software
  - JFLAP
  - ALICE
- Engaging in other ways



Yesterday – talked about JFLAP

- **J**ava **F**ormal **L**anguages and **A**utomata **P**ackage
- Instructional tool to learn concepts of Formal Languages and Automata Theory
- Topics:
  - Regular Languages
  - Context-Free Languages
  - Recursively Enumerable Languages
  - Lsystems
- With JFLAP your creations come to life!

JFLAP in CPS 140/334 at Duke

- Lecture
  - Demo how to use JFLAP
  - Solve a problem using JFLAP with the class
    - Give them time to think about it first
    - Either from scratch, or give them an attempt that needs to be fixed
  - Teach conversions using an example
  - Run examples, some with exponential time

www.cs.duke.edu/courses/spring14/compsci334

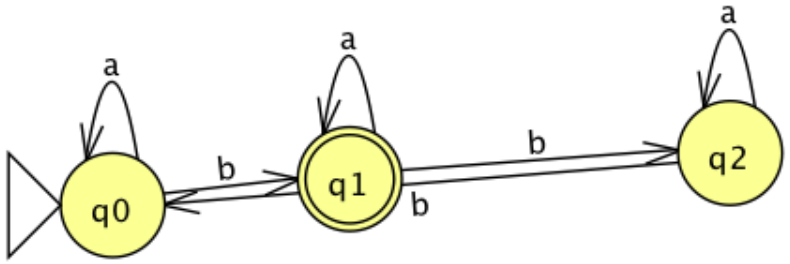
JFLAP in CPS 140 Homework

- Spring 2005 - 10 of 11 hwks used JFLAP
- Use JFLAP to check your answer
- Turn in a JFLAP file
- Grading – use multiple run window
  - Type in data once, it stays around

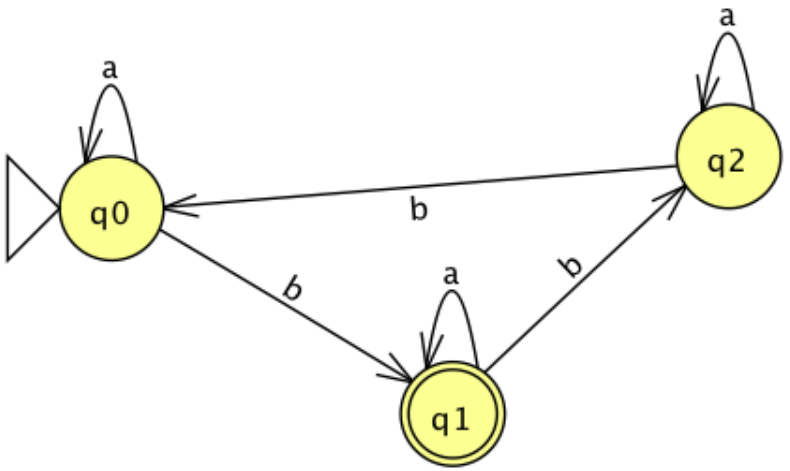
Use of JFLAP by Instructor

Showing how to layout items

Poor:

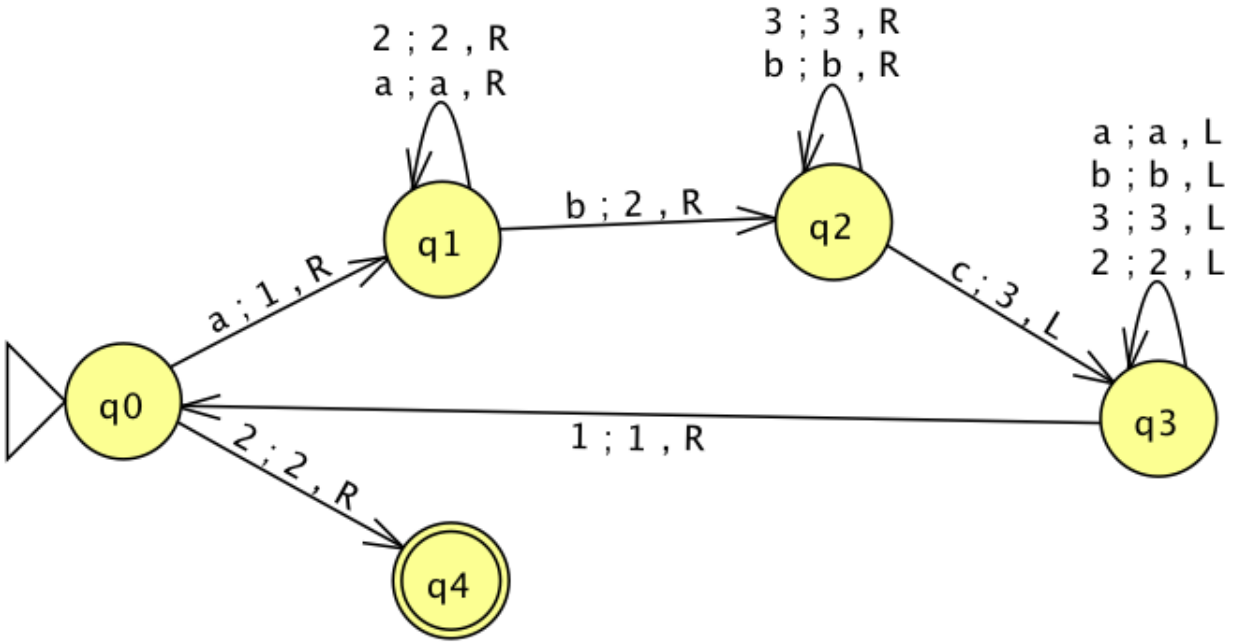


Better:



Use of JFLAP by Instructor

Is this correct for $a^n b^n c^n$?



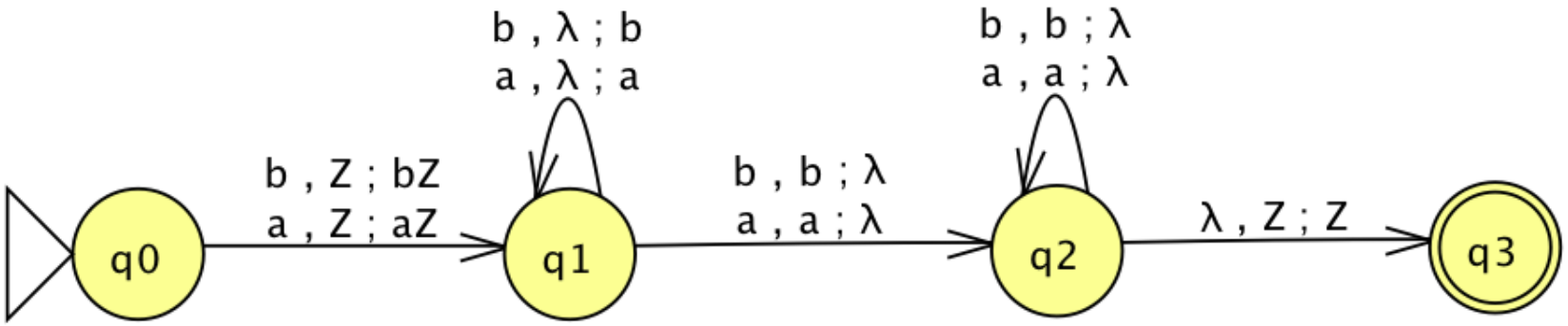
How do we fix it?

Use of JFLAP by Instructor

Experimenting with Difficult Concepts

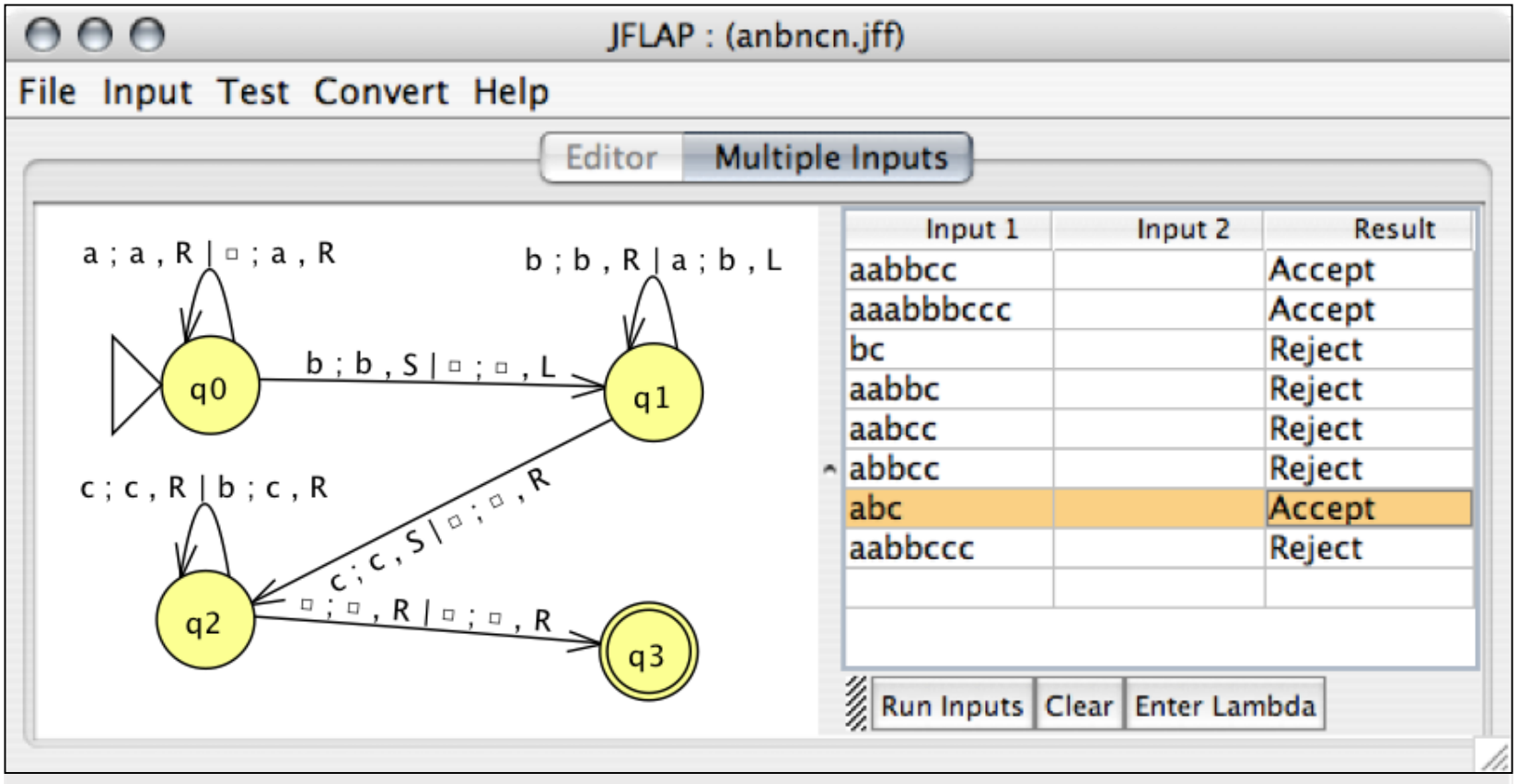
Nondeterminism: ww^R

- Students attempt at desk - difficult: want to find the “middle”
- Instructor solves with class using JFLAP



Use of JFLAP by Instructor

Testing Student Programs



Use of JFLAP by Instructor

Relate to other CS Concepts

Running Time

- Consider $a^n b^n c^n$
  - one-tape TM $O(n^2)$
  - two-tape TM $O(n)$

Other Uses of JFLAP by Instructor

- Demonstrate Nondeterminism
- Demonstrate the running of a CFG to a PDA using LR method

  Which lookahead do you choose?
- Demonstrate a transformation from one form to another

  Example: PDA to CFG
- And many other uses...

JFLAP Student Use

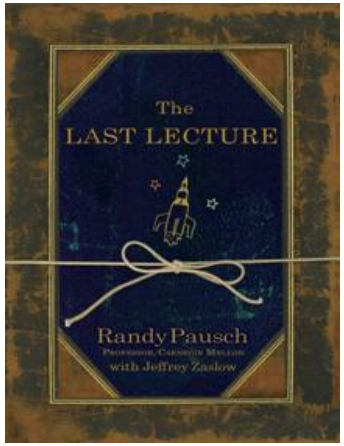
- Recreate and experiment with instructor's examples
- Use with Homework
- A study aid - create additional examples
  - explore concepts in depth
  - weaker students get more feedback

Alice Programming Language

- Create interactive stories or games
- Learn programming in an easy way, drag-and-drop your code
- Problem solving with visual feedback
  - Logical thinking, Computational thinking
- Along the way, learn computer science concepts:
  - Loops, classes, methods, functions, arrays

Alice Developed by Randy Pausch

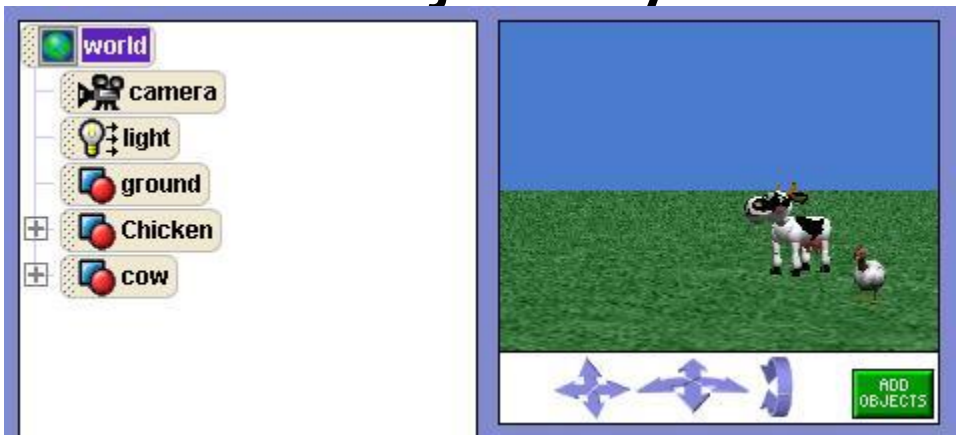
- Carnegie Mellon University
- Virtual Reality Researcher
- Wrote the Last Lecture
- Died of Pancreatic Cancer in 2008



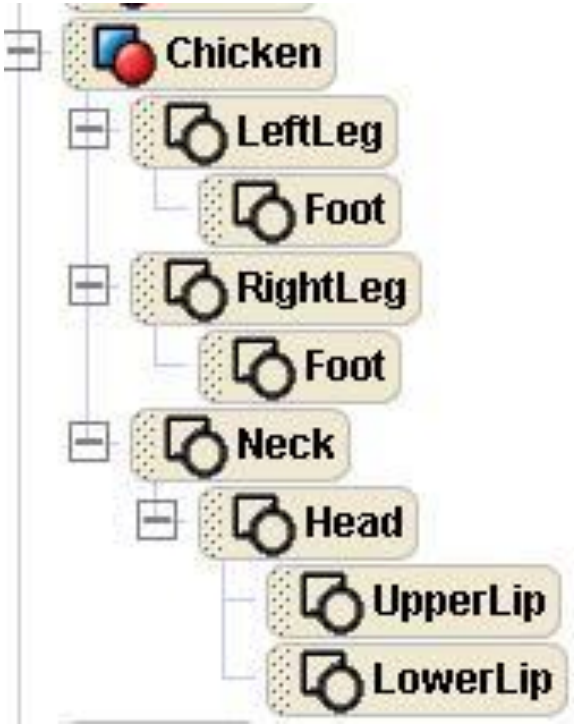
More on … Alice Programming Language

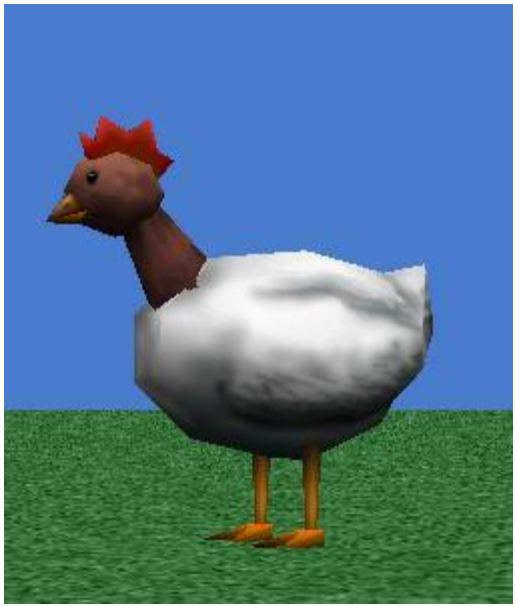
- Has libraries of 3D objects

- Keeps Track of objects you select



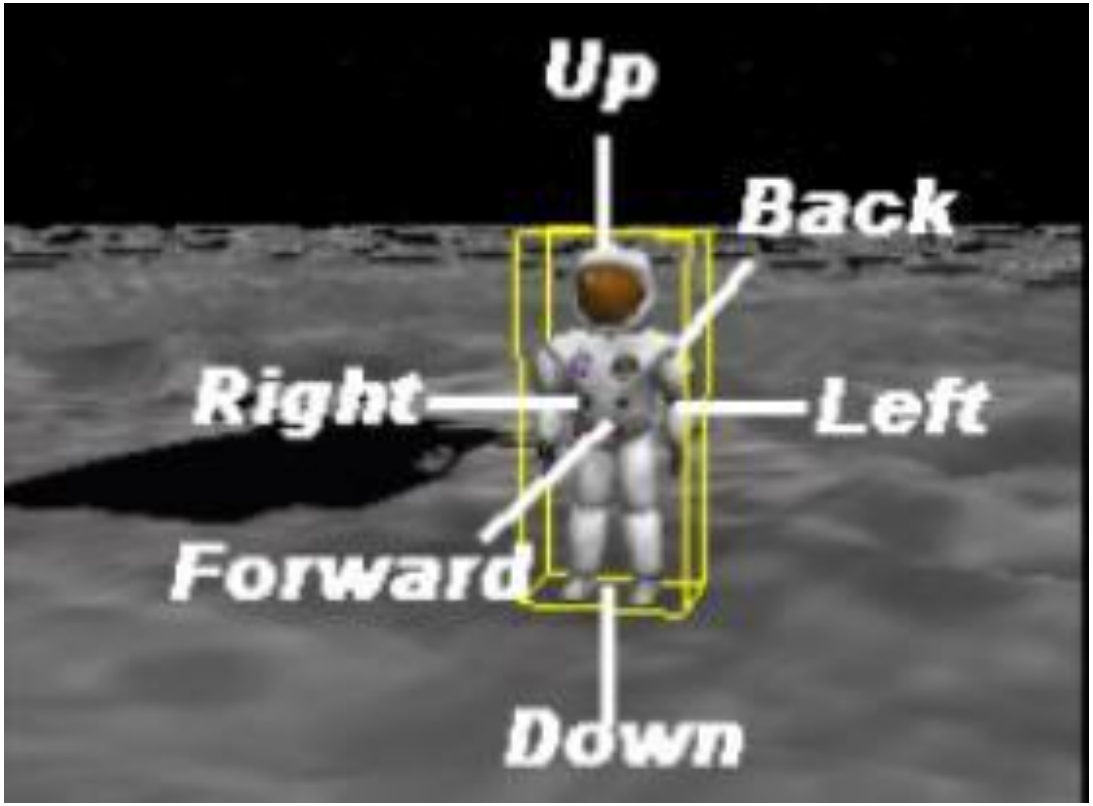
Objects Have Multiple Parts that are moveable





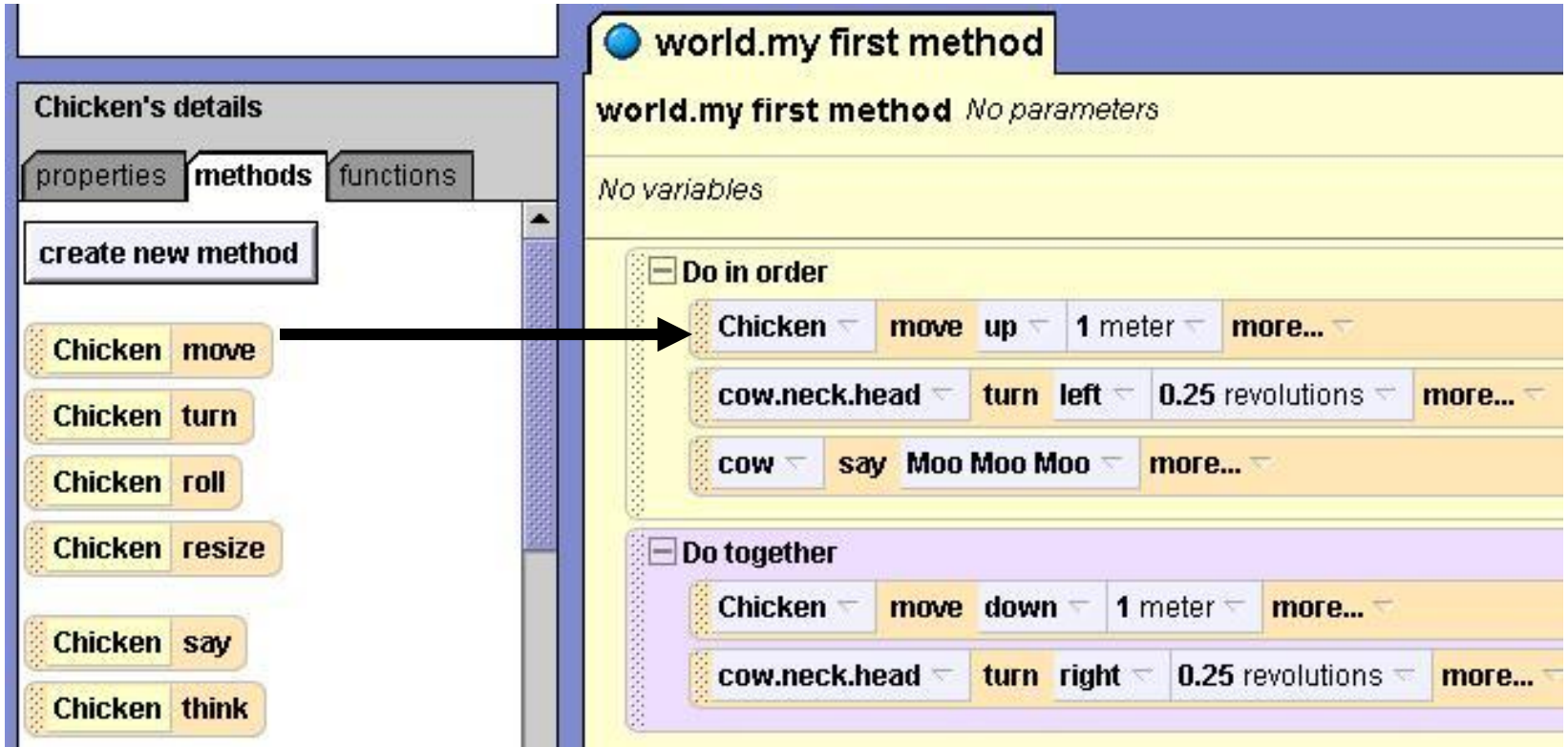
Object Position

- Objects
  - Are positioned in 3D space
  - Have six degrees of freedom



Alice Code is Easy to Learn

Select Code, Drag-and-Drop code in program



Play Alice Animation

- Chicken rises, cow turns head and talks

Adventures in Alice Programming Grades 5-12 Outreach

www.cs.duke.edu/csed/alice/aliceInSchools

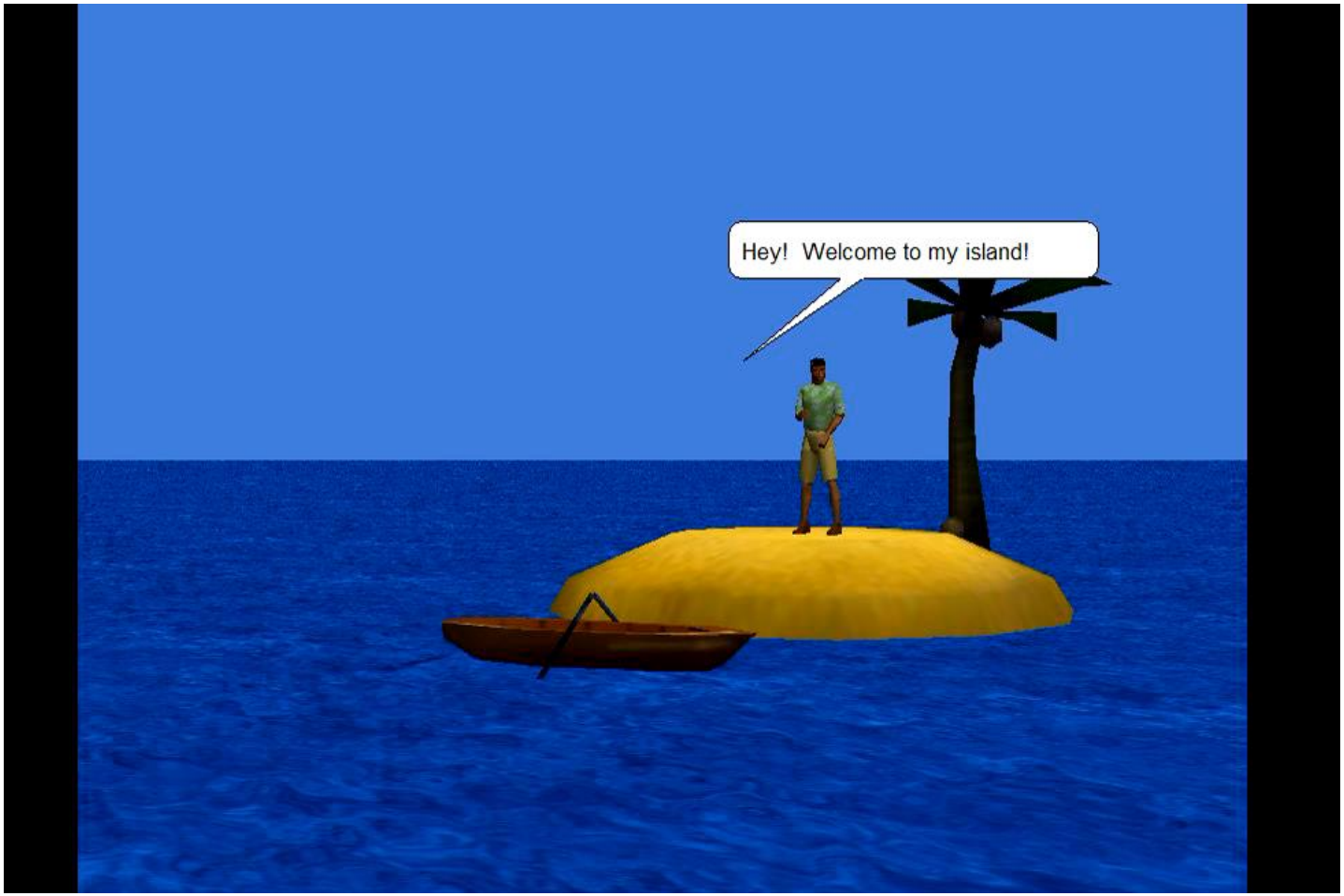
Adventures in Alice Programming

- 2-week Teacher workshops
  - Over 200 teachers, middle school, high school, some elementary
  - First week Teach Alice, Practice
  - Second week - Develop Lesson Plans
  - One-week follow-up workshop the following summer
  - Summers 2008-2015, funding for lodging
- Main Sites:
  - Duke University, Durham, NC
  - Charleston/Columbia, SC
  - San Jose, CA (starting 2014)

Getting Started Tutorials

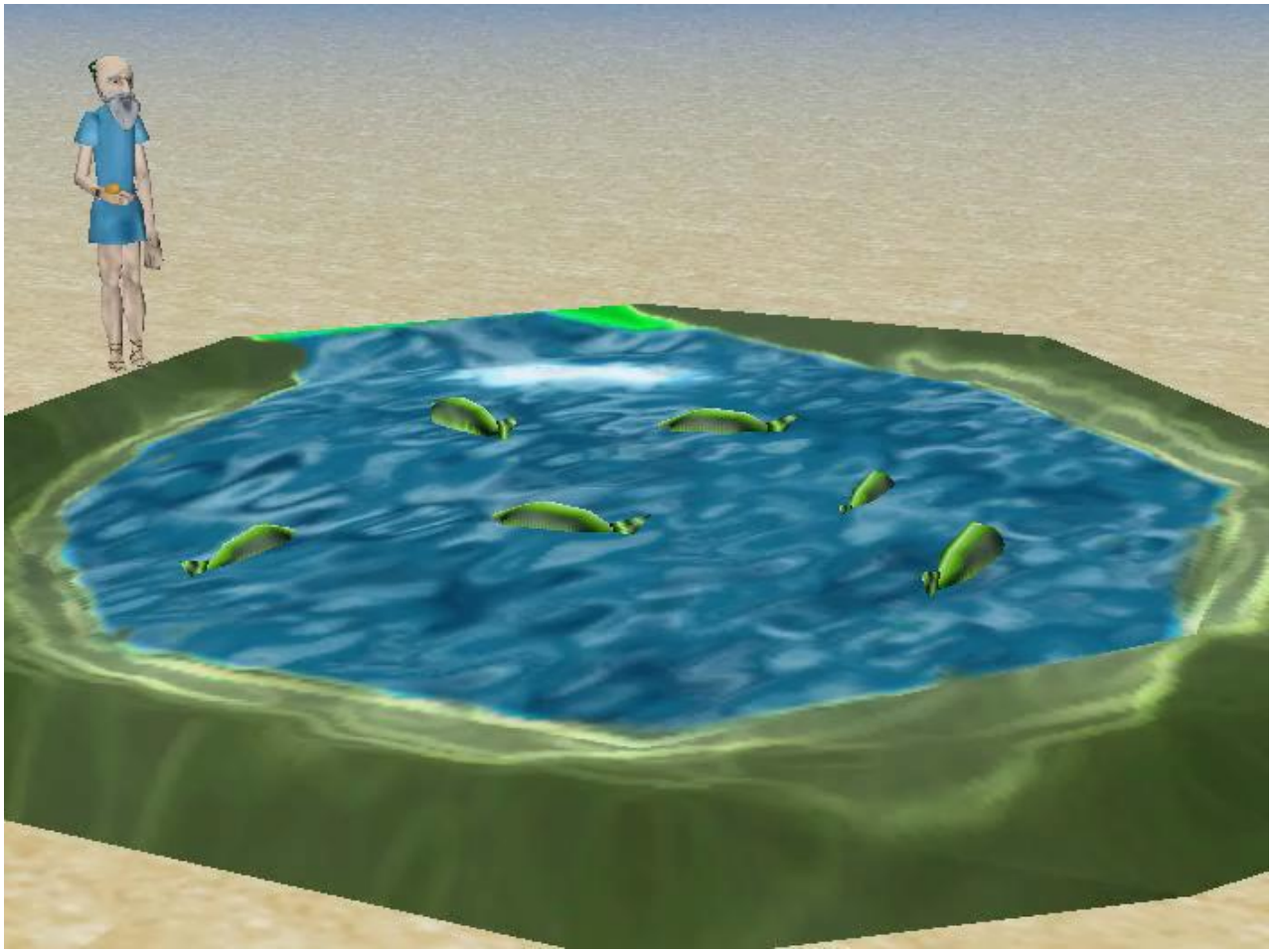
- One-hour tutorial
  - Covers placing objects, setting camera views, basic commands, writing methods and events
- 3 versions of it – pick story your students will like

Getting started tutorial
One Hour

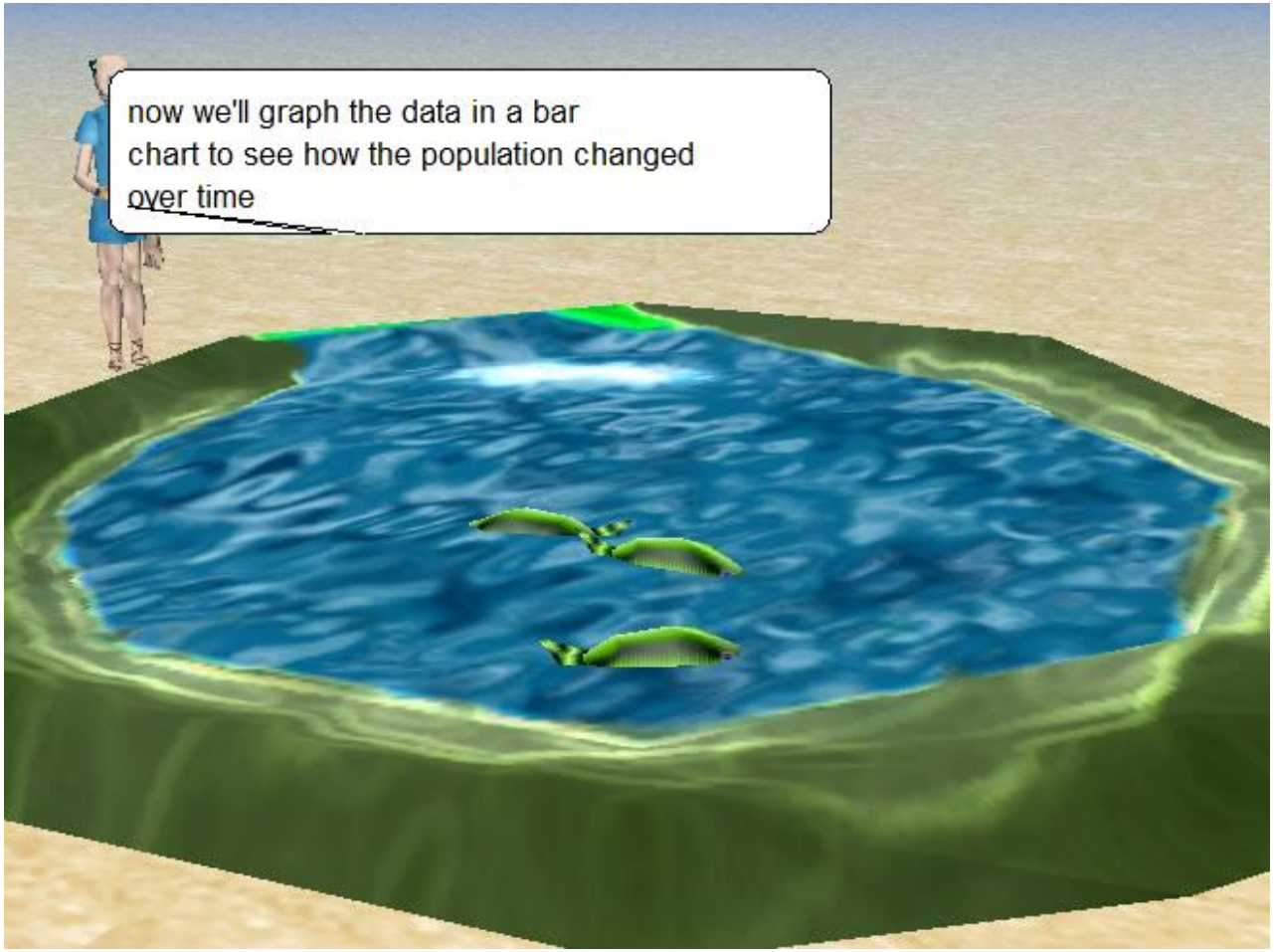


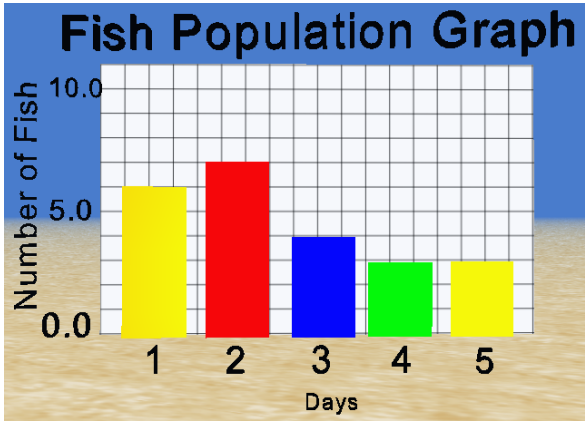
Science Example
How a volcano is formed

Science – Population Change



Science – Population Change (end)





Foreign Language simple

Focus on math
Math Example – Plotting Numbers

Math Story on Fractions

Curriculum Materials

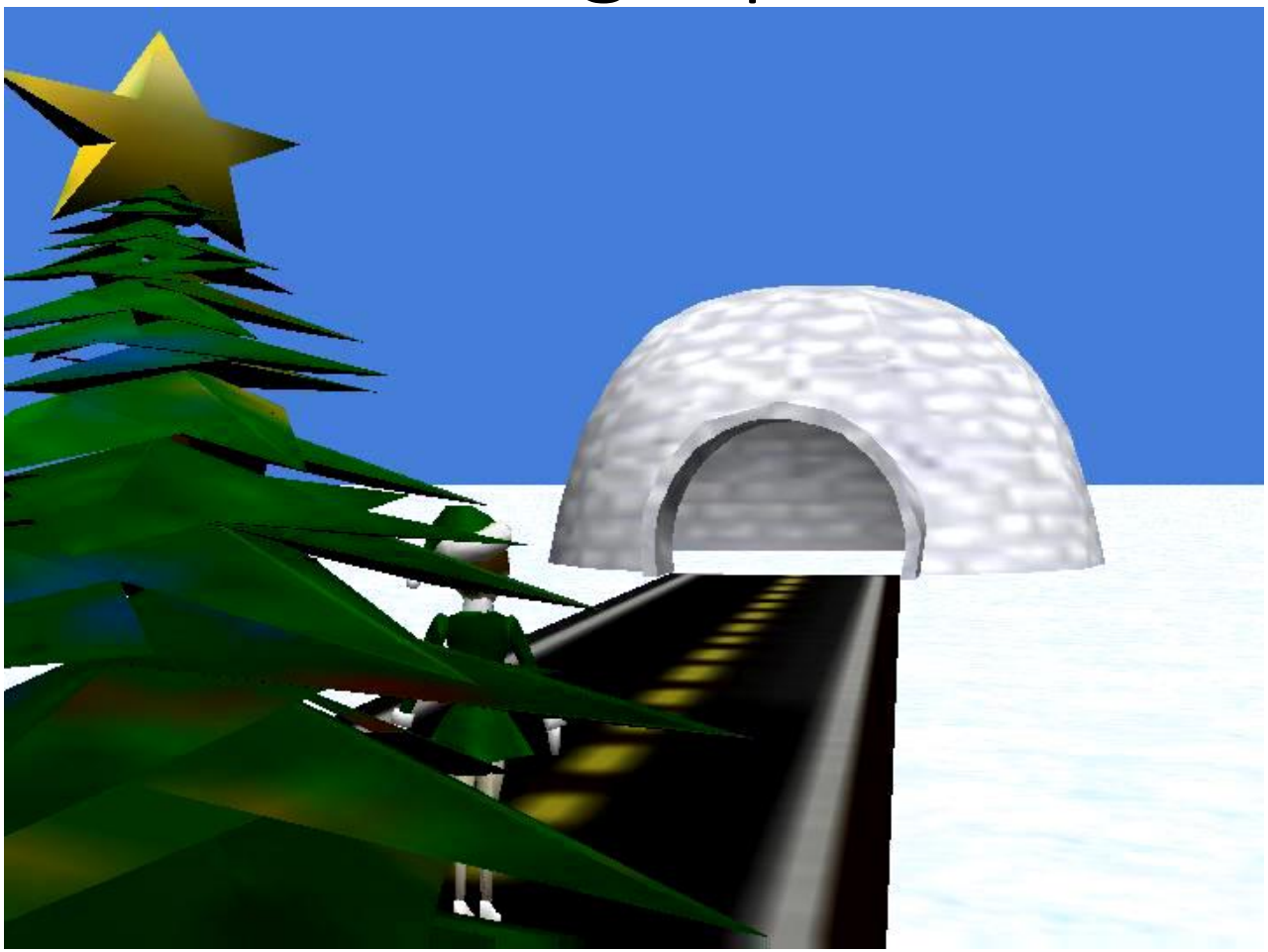
- Over 90 tutorials available for free
- Beginner, advanced, challenges, projects
- Paper handouts and video
- Teacher lesson plans in many disciplines

Tutorial for Project: Book Report

Tutorial for Adventure Game – Find objects in order

Sample tutorial: Scene Change

New Tutorial – Camera views following a person



Harry Potter Challenge

- Mix of programming and math challenges

Harry Potter – Math/computing Level 1 Charms - before

Harry Potter – Math/Computing Level 1 Charms - after

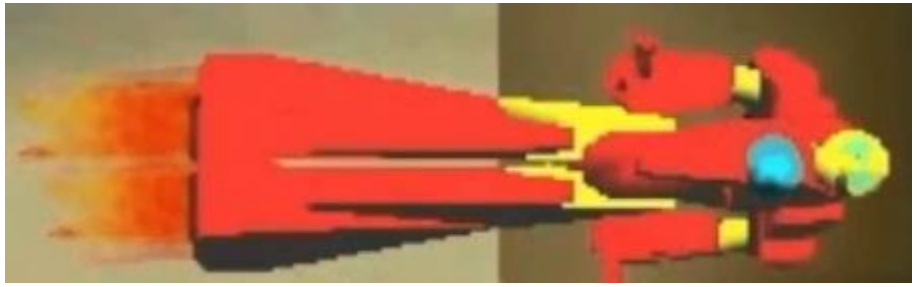
Other Example Challenges
Boat
Calculator

Enhanced Calculator!

Fun with Alice

What a 6th grader can do with Alice - teacher Chari Distler

No Superheros in Alice



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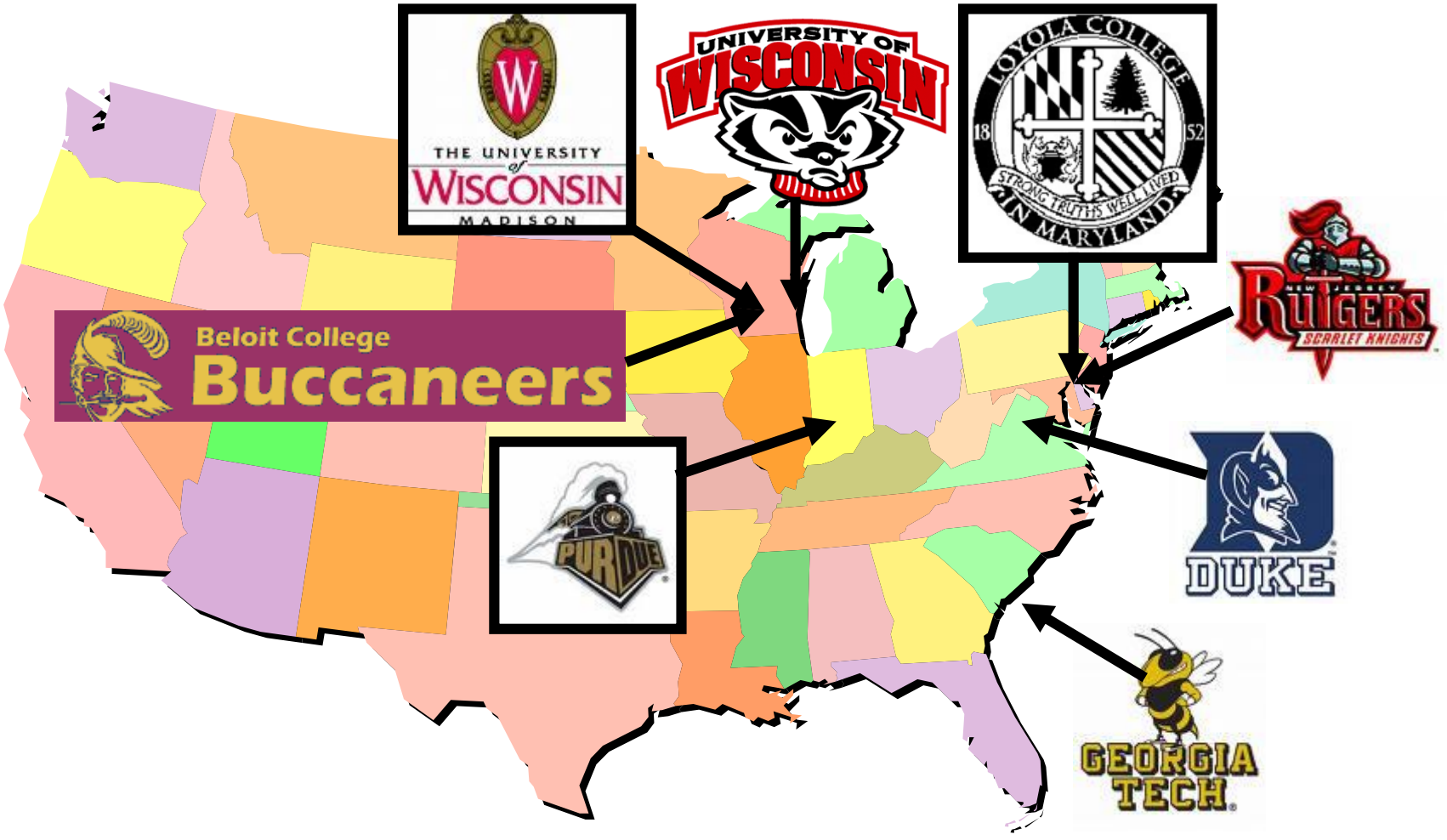
- Peer-led team learning
- Engaging in other ways

Motivation for Peer-Led Team Learning

- Goals
  - Increase number of women and underrepresented groups
  - Increase retention and enthusiasm
- Approaches
  - Active Recruiting of Incoming First-year students
  - Optional/Required of registered students

8 NSF-FUNDED SCHOOLS



What is PLTL?

- Related to a course
  - Students solve problems in small groups (4-8 students) weekly in addition to regular class meeting
  - Interesting exercises to be solved as a group
  - Led by trained undergraduate student leaders who facilitate group learning
- Used in Chemistry for about 12 years, www.pltl.org
- Beneficial to both students and student leaders

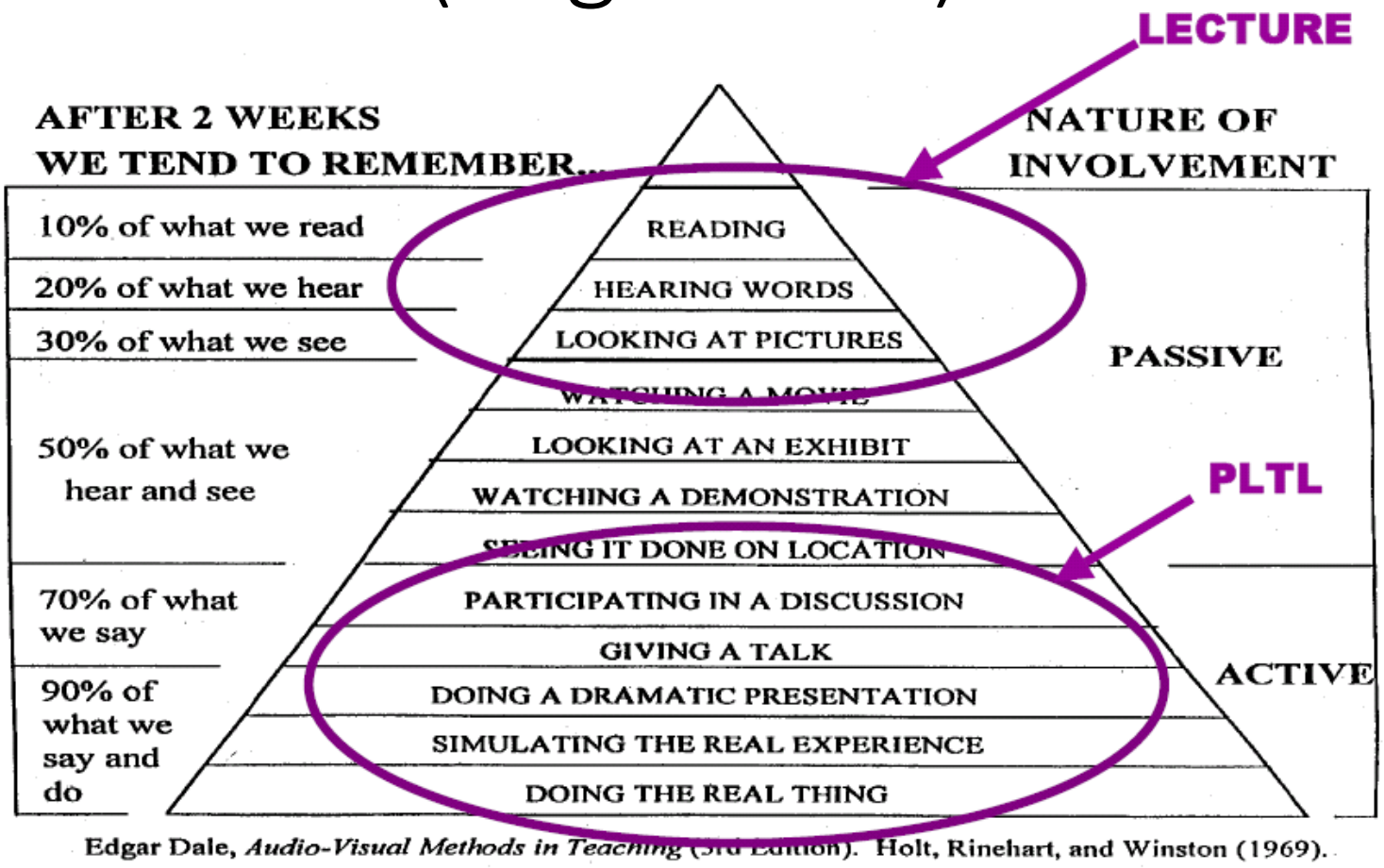
Groups != Discussion Section

- Students helping, learning from other students
- Less authoritative; liberate and empower students
- Promote Active Learning, encourage teamwork
- More fun!

Why PLTL?

- Factors affecting intellectual development in college
  - Student/faculty interaction outside the classroom
  - Involvement on campus through various forms of community-building activities
  - Involvement with student peer groups
  - “peer group – the most potent source of influence on growth and development during the undergraduate years.”
    - Astin, A. W., (1993) What Matters in College? Jossey-Bass Publishers, San Francisco. pg. 394-398.

Cone of Learning (Edgar Dale)



Edgar Dale, *Audio-Visual Methods in Teaching* (3rd Edition). Holt, Rinehart, and Winston (1969).

Effects on Students

- Better/deeper understanding of material
- Lower drop rates
- Better grades (usually)
- Formation of social groups
- Very high satisfaction

Effects on Peer Leaders

- Better understanding of the material
- Increased confidence to continue in CS
- Appreciation for different teaching /learning styles
- Improved leadership skills
- Collegial relationship with faculty

What is ESP?

- Emerging Scholars Program
  - Used in math and science courses
  - Recruits under-represented groups
  - Works in small groups on challenging problems
- Benefits
  - Earn Higher Grades
  - Increases enthusiasm for math and science
- "Calculus and the Community – A History of the Emerging Scholars Program" by Rose Asera, 1991, College Board.

Defining PLTL in CS (also called ESP-PLTL)

- Small groups meet related to a course
  - Not everyone from the course
  - Build friendships to help support you through major
- Active recruiting
- Aim for gender balance
- Undergraduate peer leaders
- Solve challenging problems

Peer-Led Team Learning in CS (PLTL in CS)

- Combines components from PLTL and ESP
- Eight Universities – Fall 2005 – Spring

Beloit College (WI)

Duke University (NC)

Georgia Tech (GA)

Loyola College (MD)

Purdue University (IN)

Rutgers University(NJ)

University of Wisconsin Madison (WI)

University of Wisconsin Milwaukee (WI)

- www.pltlcs.org

Supported by the National Science Foundation collaborative Grants CNS-0420436, 0420343, 0419340, 0420433, 0420358, 0420312, 0420368, 0420337, 0638510 and 0638499 and a donation from Microsoft.

PLTL in CS variations among 8 universities

- Some focus on non-majors course
- Some focus on CS 1
- Some focus on both (one year)
- Some have just women, most are mixed
- Some include everyone, most are subset

- All use active recruiting and undergraduate peer leaders
- All use problem solving in small groups outside of main class period

Duke University -"PLTL in CS" version Emerging Scholars Program (DES)

- One year program – four courses total
  - First semester
    - Main course: Non-majors course: CPS 4 (Alice) (1 credit)
    - Problem Solving Seminar course: CPS 18S (1/2 credit)
  - Second Semester
    - Main Course: CS 1 course: CPS 6 (Java)
    - Problem Solving Seminar course: CPS 18S (1/2 credit)
  - Active Recruiting (email to targetted groups, accepted student fairs, invite students in main course)
  - Gender balanced
  - Outside Speaker/Field Trip
  - Undergraduate Peer Leaders in Problem Solving Seminar

CompSci 18S: Problem Solving Seminar

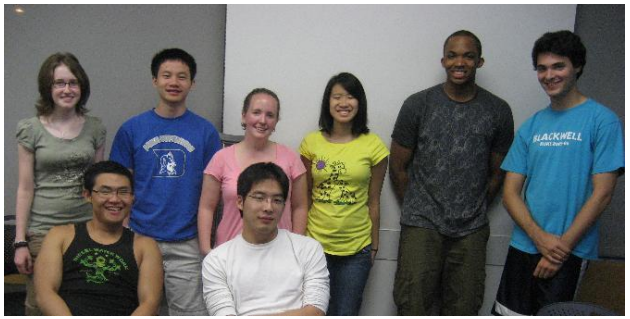
- 2 peer leaders, about 12 students, (1 professor)
- Solve problems in groups of 4
- Either general computer science problems or related to the main course
- Subset of students from main course, those who want the group experience
- Peer leaders trained in workshop, meet weekly

2 Main Courses: Non-majors (Alice) and CS 1 (Java)

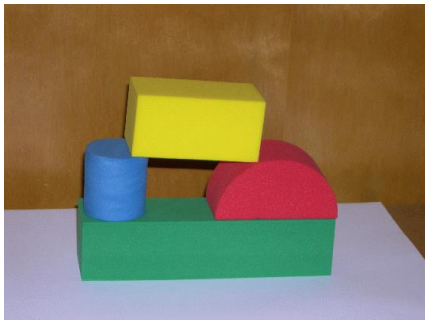
- Workshop format
  - Lecture 10-20 minutes
  - Students program rest of class
  - Students work in pairs ("pair programming")
    - Two people, two laptops, consult a lot
  - Assigned seats and pairs, change every 2-3 weeks
- About 35-50 students

2 Main Courses: Undergraduate role

- About 8-10 undergraduate teaching assistants
- Roles:
  - Attend the “workshop lecture” to assist
  - Meet weekly
  - Grade and hold consulting hours
  - Includes the two peer leaders from the problem solving seminar



Example of Problem Solving: Be A Robot



- Group of 4 – brain, eyes, 2 hands
- Only brain knows what you are building
- Only eyes can see
- Must work together precisely like a robot

Example of Problem Solving: Sorting

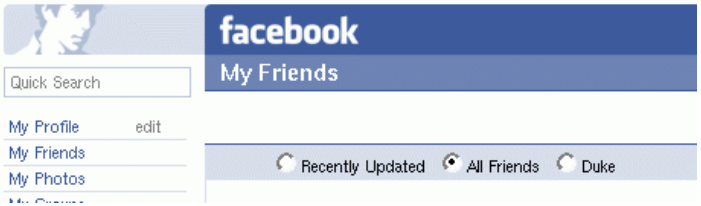
- Give students an envelope of words – each word on a separate sheet of paper
- In groups, sort the words
- write down the algorithm you designed

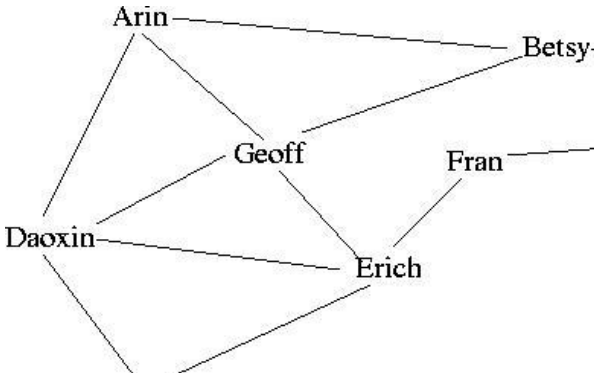
Sorting (cont)
Questions to think about when organizing the words…

- How many words are there?
- How many words start with “m”?
- How many words end in “k”?
- What is the 66th word?
- How many words have “her” in them?
- What is your favorite word?

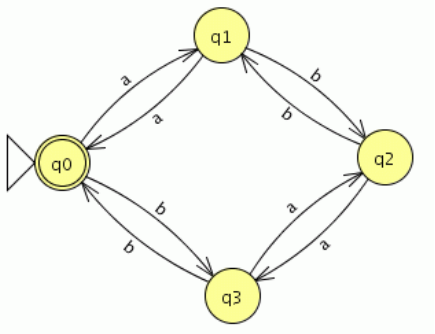
Example of Problem Solving - Graphs

- Graph of all friends (of everyone in class, at your university)
- Problems
  - Find number of friends of friends of someone
  - Find the center of the graph – person with smallest sum of shortest distances

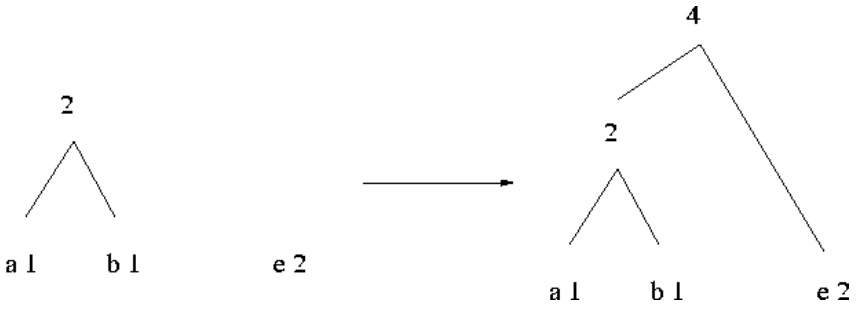


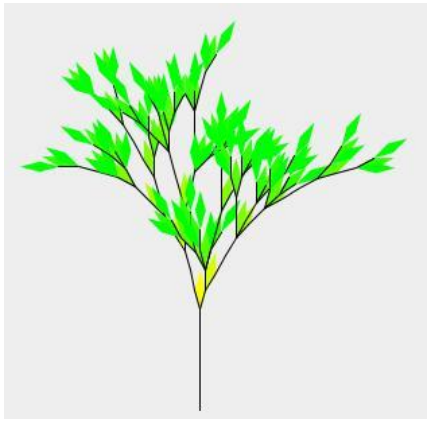


Other Examples



- Finite State Machines
- Turing Machines
- Random Numbers
- Compression
  (Huffman coding)
- Sudoku, Jumble
- L-Systems
- Genomics





	6		1		4		5	
		8	3		5	6		
2								1
8			4		7			6
		6				3		
7			9		1			4
5								2
		7	2		6	9		
	4		5		8		7	

Results from Study

- Susan Horwitz, Susan Rodger, Maureen Biggers, David Binkley, C. Kolin Frantz, Dawn Gundermann, Susanne Hambrusch, Steven Huss-Lederman, Ethan Munson, Barbara Ryder, and Monica Sweat, Using Peer-Led Team Learning to Increase Participation and Success of Under-Represented Groups in Introductory Computer Science, Fourtieth SIGCSE Technical Symposium on Computer Science Education, 2009

Results:
Why did women enroll in PLTL in CS?

41 women responded in 2005-06

60.5% mailed invitation

15.6% other

12.8% info during orientation

9.8% academic advisor recommendation

9.8% class announcement

4.9% parent recommendation

Results - Why enroll in main course?

31 female/49 male responses 2005 (select all that apply)

F	M	Reason
71.0%	22.5%	I received an invitation
67.7%	28.6%	To see whether I enjoy CS
29.0%	40.8%	Meets requirement for my major
25.8%	79.6%	I know I am interested in CS
19.4%	18.4%	Programming is useful job-market skill
16.1%	57.1%	I plan to major in CS

Results - Recruiting

- Percentage of women and minorities was higher in ESP-PLTL
- This is over all institutions from 2005-2007.

	ESP-PLTL		Main Course	
	#	%	#	%
Female	122	33.4%	673	29.0%
Minority	43	11.8%	218	9.4%

Retention Data

Retention Data, All Institutions Combined (2005 - 2007)						
	ESP-PLTL		**Non ESP-PLTL**		**Total (All Students)**	
	#	%	#	%	#	%
Completed	383	93.2%	2363	88.0%	2746	88.7%
Dropped	28	6.8%	323	12.0%	351	11.3%
Total	411	100.0%	2686	100.0%	3097	100.0%

Final Grade Data, all Institutions 2005-2007

	All ESP-PLTL		**All Non-ESP-PLTL**		**Total (All Students)**	
	#	%	#	%	#	%
B or better	219	80.2%	1130	68.4%	**1349**	**70.1%**
Less than B	54	19.8%	522	31.6%	**576**	**29.9%**
Total	**273**	**100.0%**	**1652**	**100.0%**	**1925**	**100.0%**

	ESP-PLTL Female		**Non-ESP-PLTL Female**		**Total (All Females)**	
	#	%	#	%	#	%
B or better	70	83.3%	295	70.1%	**365**	**72.3%**
Less than B	14	16.7%	126	29.9%	**140**	**27.7%**
Total	**84**	**100.0%**	**421**	**100.0%**	**505**	**100.0%**

Advantages for Peer Leaders (telephone interview)

- Common themes emerged
  - Improved Leadership skills
  - Opportunity to try out educator role
  - Reinforcement of understanding CS concepts
  - Increased confidence to continue in field
  - Friendships with students
  - Would recommend experience to others

Summarizing results

- Active Recruiting increased number of women
  - Email/mailed invitation was most effective
- Retention of PLTL in CS students was higher
- Grades of PLTL in CS students was higher
- Friendships and Bonding occurred with students
- Advantages for Peer Leaders too
- PLTL in CS workshop April 2007 at Duke

Outline

- Lecture formats
- Prepare for Class
- Class participation
- Engaging with Software
- Peer led team learning
- Engaging in other ways

Engaging students in a group activities/large course

- Problem Solving in groups
  - Clickers, Google forms – compare results
  - Flip Classroom, reading quizzes (turn off at start of class)
- Acting out stories, games
  - *Everything I needed to know about teaching*… - Pollard, Duvall (SIGCSE 2007)
- Acting out algorithms with the whole class
  - Make a binary tree with the whole class
  - Calculate the height of the tree
  - *Making Lemonade … large lecture classes* – Wolfman (SIGCSE 2002)
- Acting out algorithms with a subset of students
  - Sorting algorithms – selection sort, insertionsort, etc
  - CS Unplugged activities

Example of Computer Science concept

- Children's book

This was no time for play.
This was no time for fun.
This was no time for games.
There was work to be done.

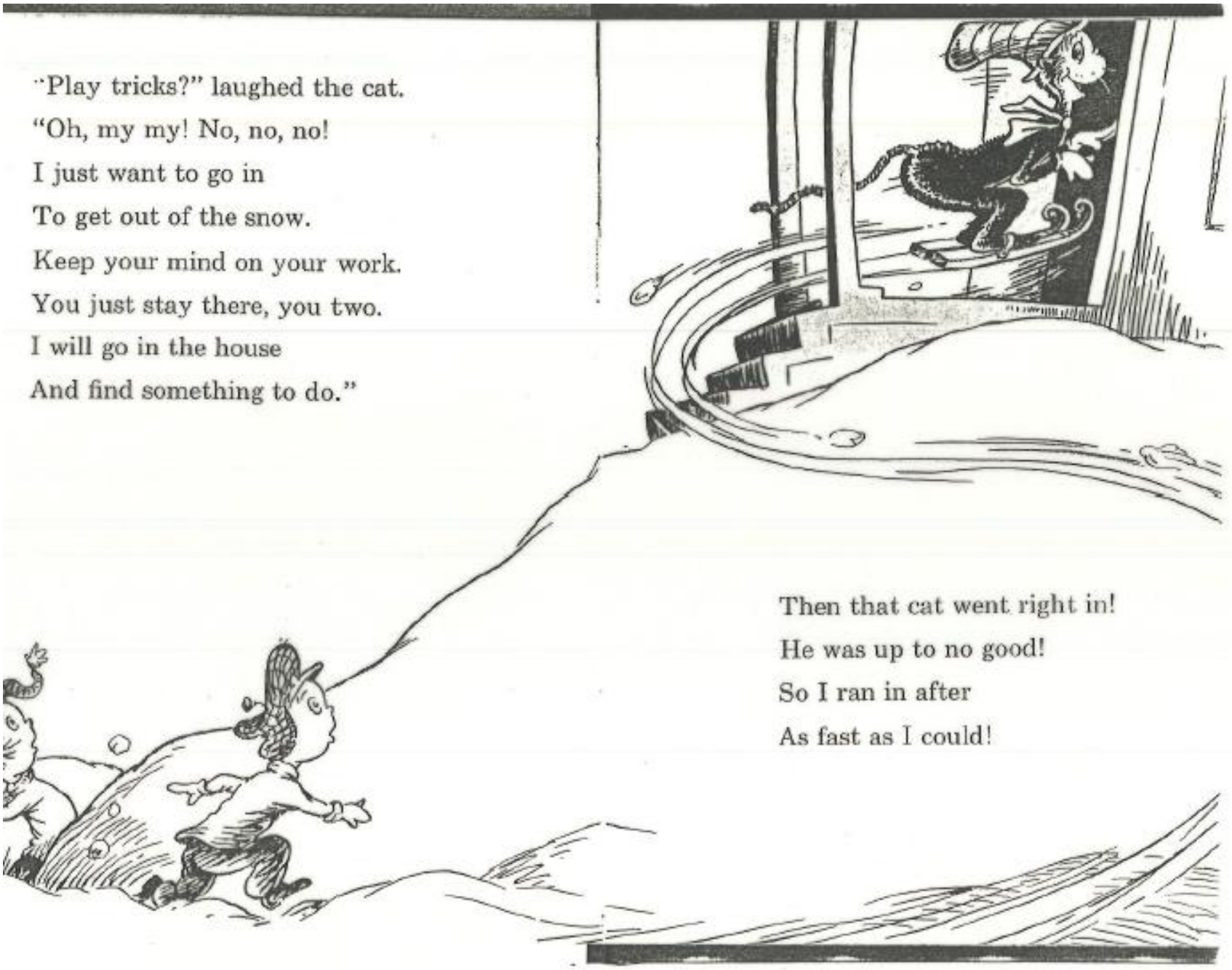
All that deep,
Deep, deep snow,
All that snow had to go.

When our mother went
Down to the town for the day,
She said, "Somebody has to
Clean all this away.
Somebody, SOMEBODY
Has to, you see."
Then she picked out two Somebodies.
Sally and me.

Well . . .
There we were.
We were working like that
And then who should come up
But the CAT IN THE HAT!

"Oh-oh!" Sally said.
"Don't you talk to that cat.
That cat is a bad one,
That Cat in the Hat.
He plays lots of bad tricks.
Don't you let him come near.
You know what he did
The last time he was here."

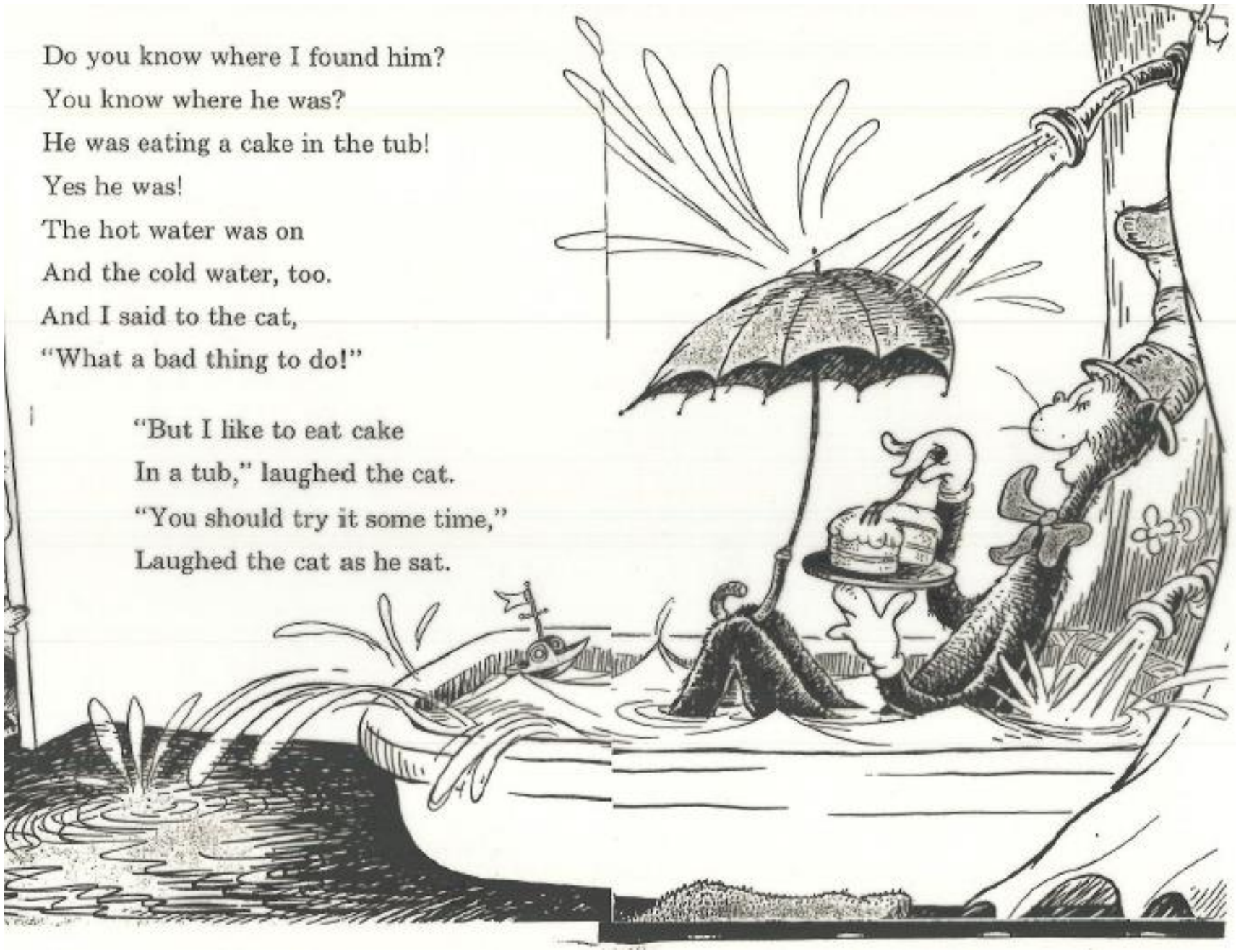
"Play tricks?" laughed the cat.
"Oh, my my! No, no, no!
I just want to go in
To get out of the snow.
Keep your mind on your work.
You just stay there, you two.
I will go in the house
And find something to do."



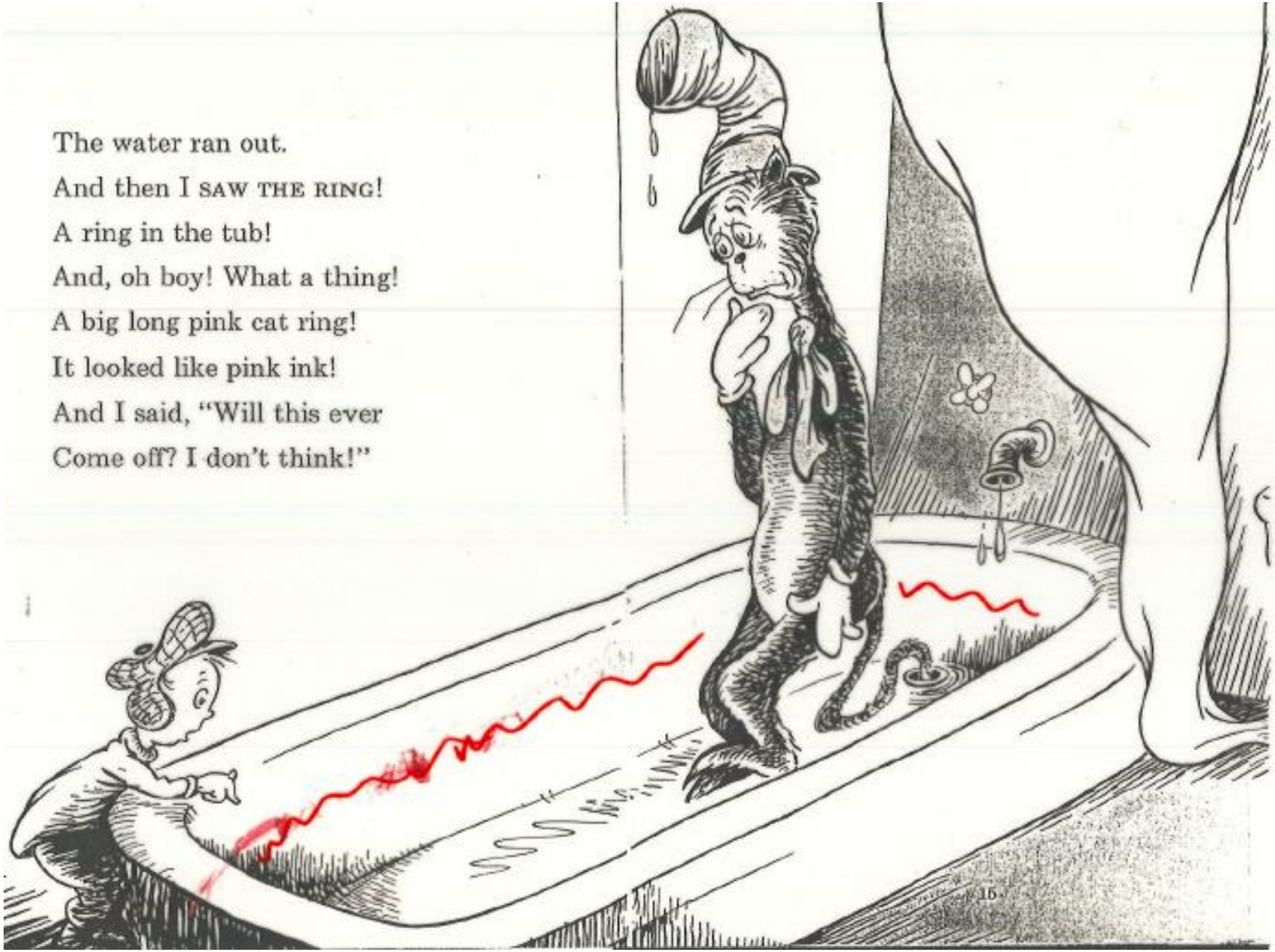
Then that cat went right in!
He was up to no good!
So I ran in after
As fast as I could!

Do you know where I found him?
You know where he was?
He was eating a cake in the tub!
Yes he was!
The hot water was on
And the cold water, too.
And I said to the cat,
"What a bad thing to do!"

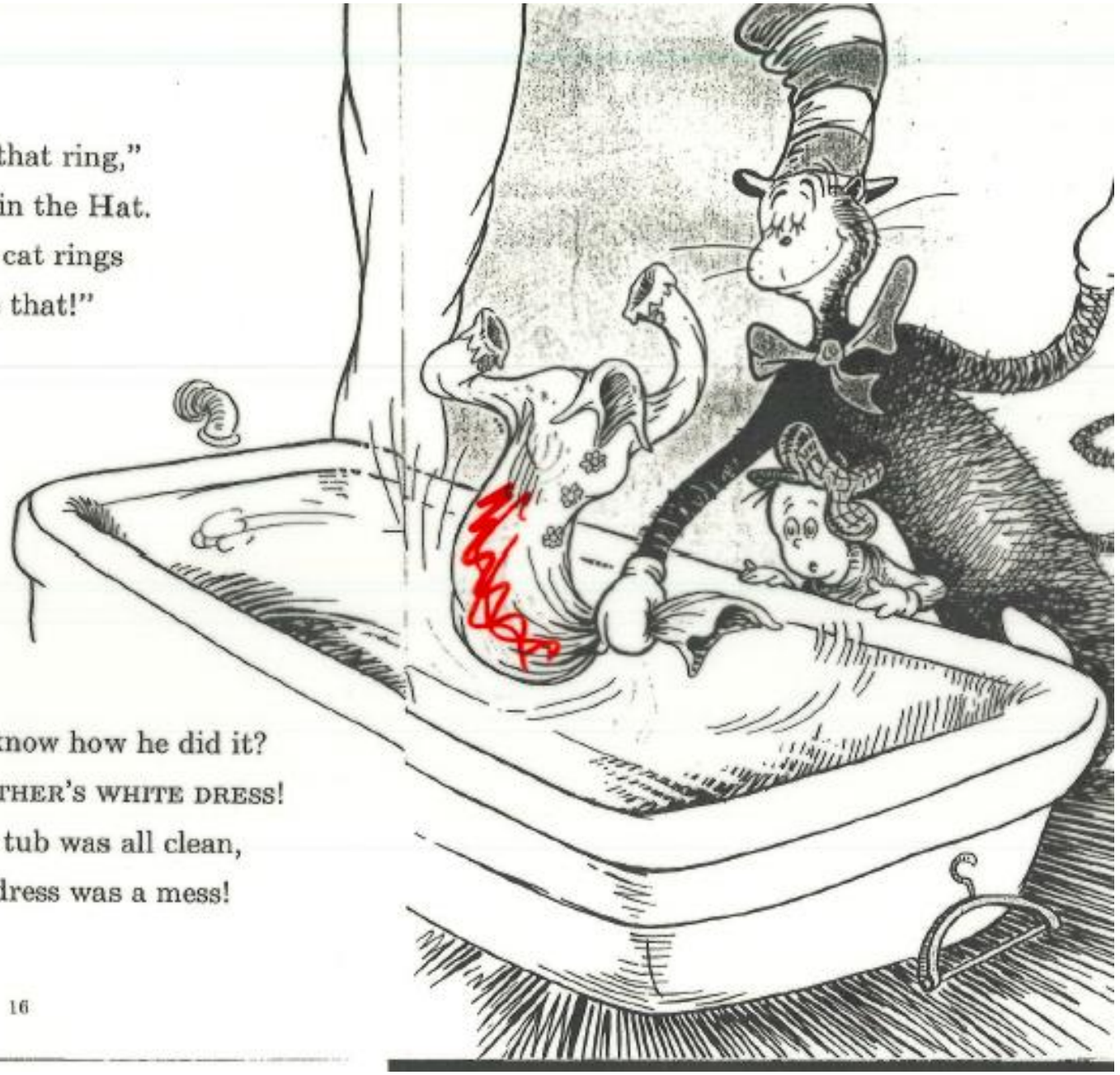
"But I like to eat cake
In a tub," laughed the cat.
"You should try it some time,"
Laughed the cat as he sat.



The water ran out.
And then I SAW THE RING!
A ring in the tub!
And, oh boy! What a thing!
A big long pink cat ring!
It looked like pink ink!
And I said, "Will this ever
Come off? I don't think!"

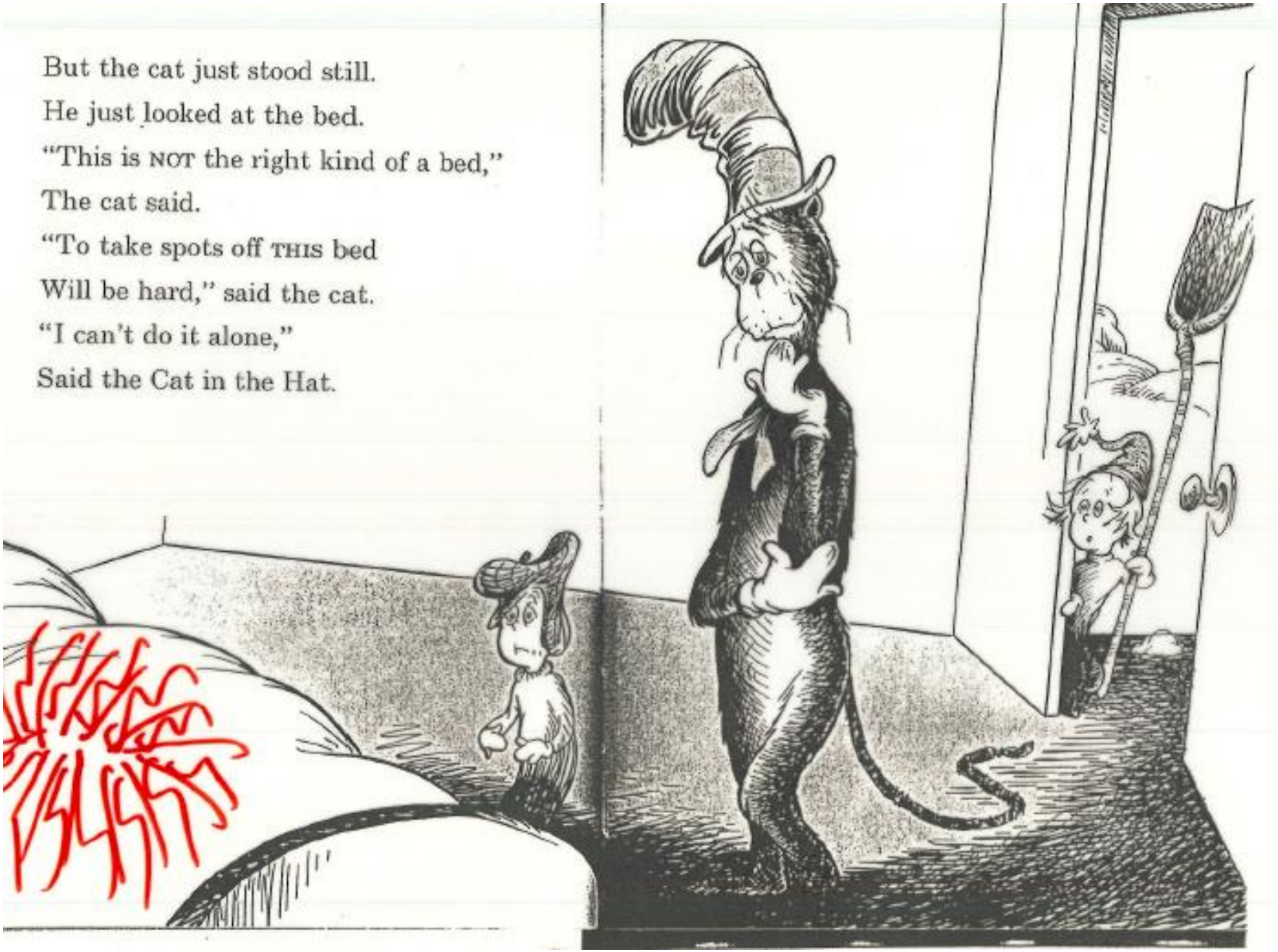


"Have no fear of that ring,"
Laughed the Cat in the Hat.
"Why, I can take cat rings
Off tubs. Just like that!"



Do you know how he did it?
WITH MOTHER'S WHITE DRESS!
Now the tub was all clean,
But her dress was a mess!

But the cat just stood still.
He just looked at the bed.
"This is NOT the right kind of a bed,"
The cat said.
"To take spots off THIS bed
Will be hard," said the cat.
"I can't do it alone,"
Said the Cat in the Hat.



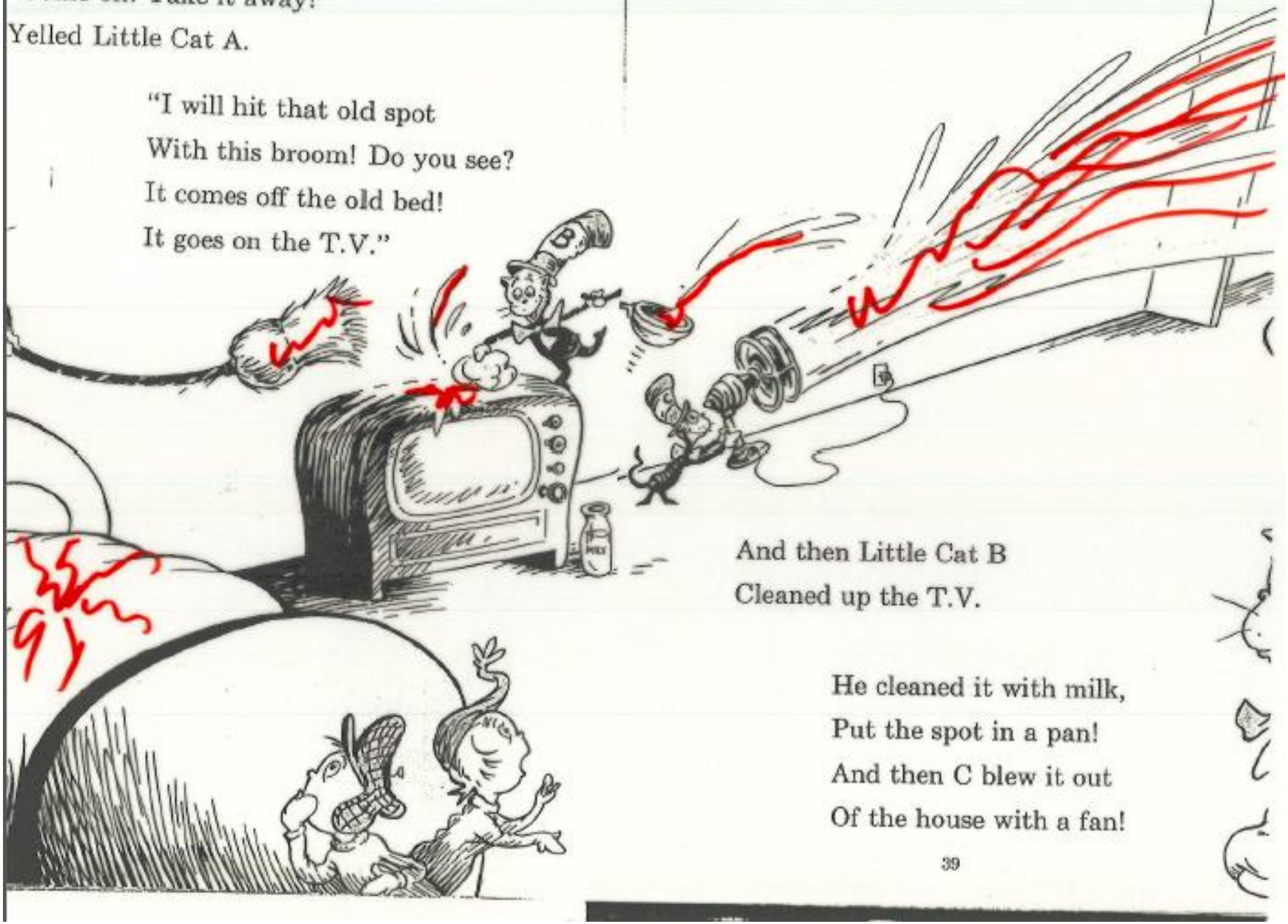
"It is good I have some one
To help me," he said.
"Right here in my hat
On the top of my head!
It is good that I have him
Here with me today.
He helps me a lot.
This is Little Cat A."

And then Little Cat A
Took the hat off HIS head.
"It is good I have some one
To help ME," he said.
"This is Little Cat B.
And I keep him about,
And when I need help
Then I let him come out."

And then B said,
"I think we need Little Cat C.
That spot is too much
For the A cat and me.
But now, have no fear!
We will clean it away!
The three of us! Little Cats B, C and A!"

"Come on! Take it away!"
Yelled Little Cat A.

"I will hit that old spot
With this broom! Do you see?
It comes off the old bed!
It goes on the T.V."

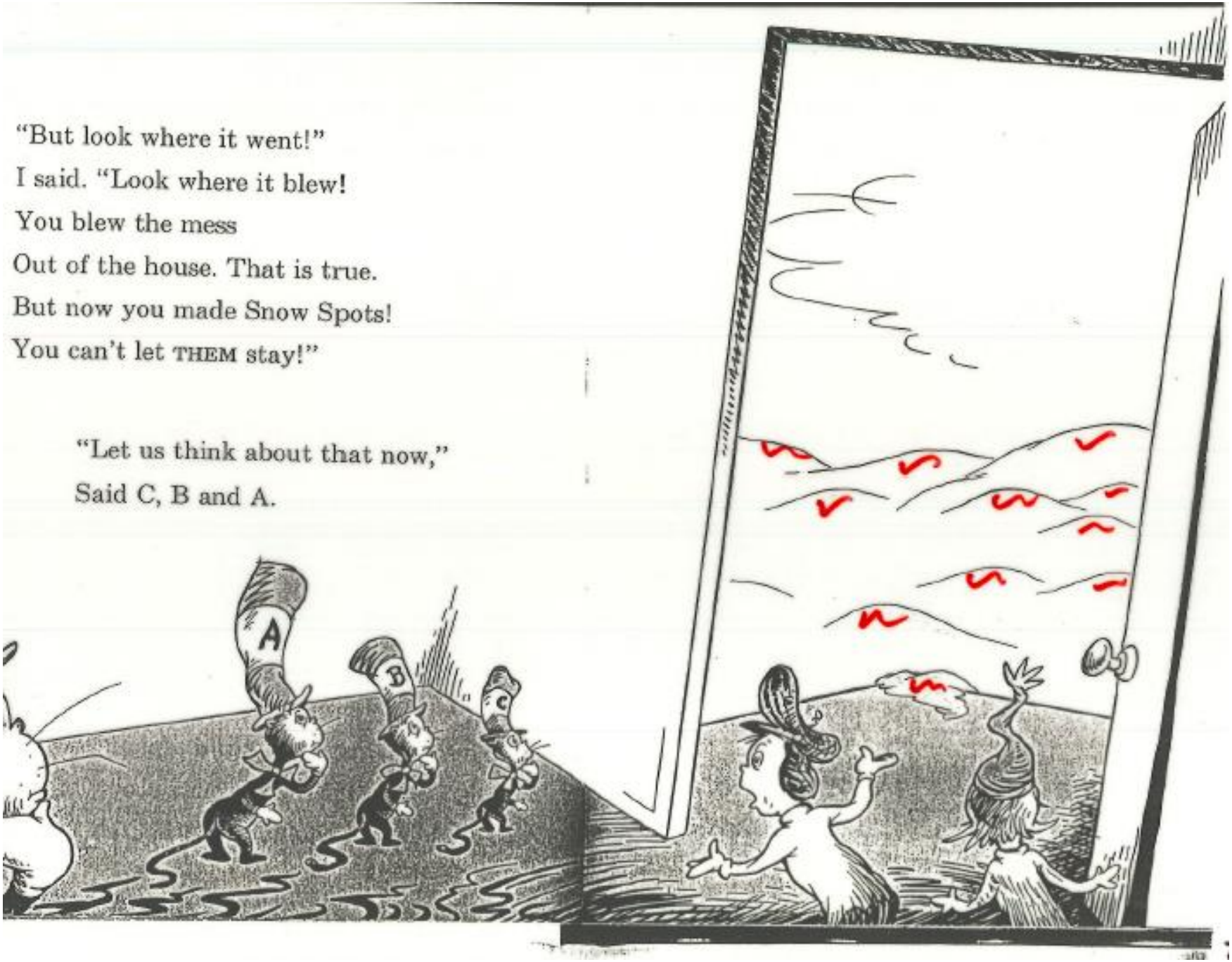


And then Little Cat B
Cleaned up the T.V.

He cleaned it with milk,
Put the spot in a pan!
And then C blew it out
Of the house with a fan!

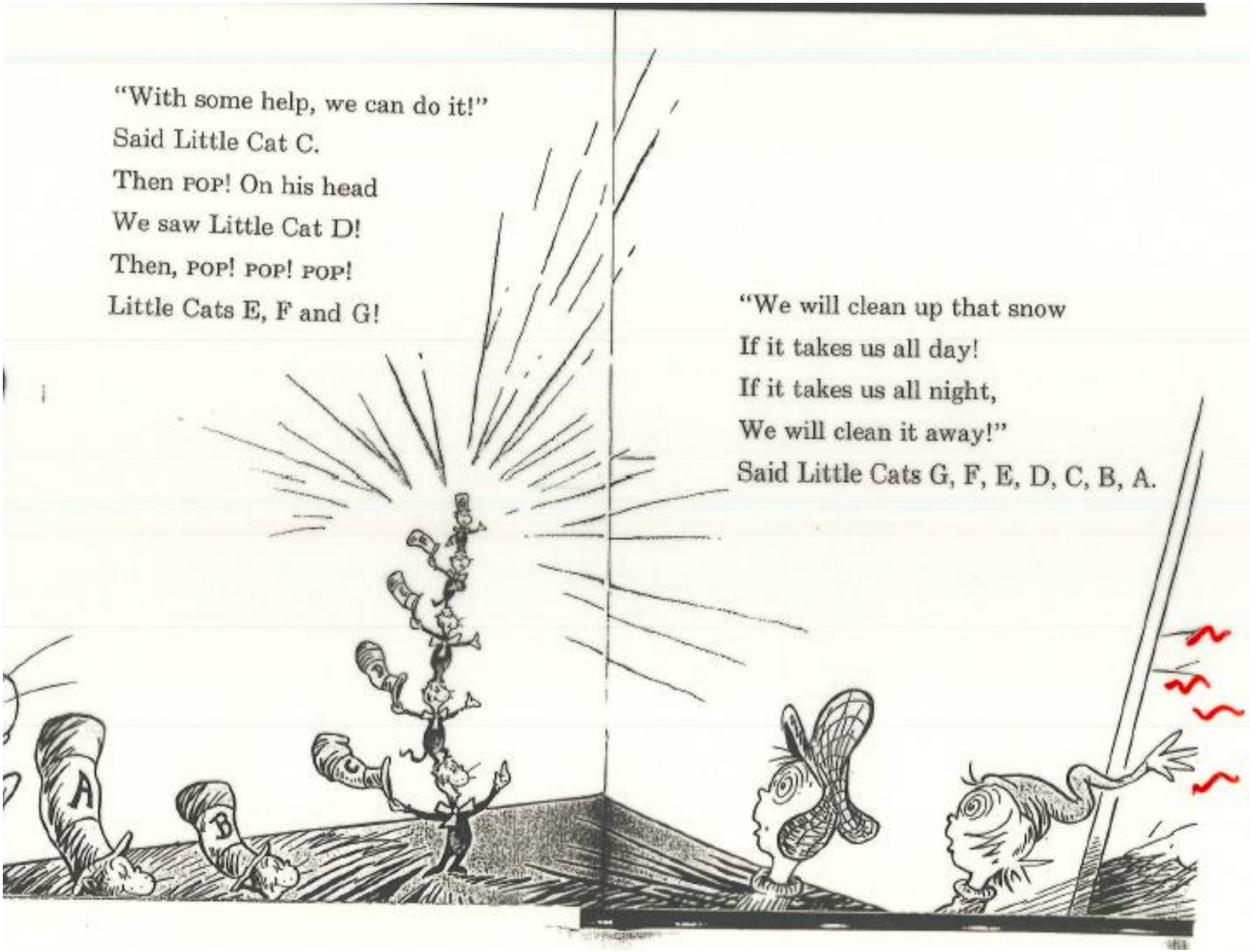
"But look where it went!"
I said. "Look where it blew!
You blew the mess
Out of the house. That is true.
But now you made Snow Spots!
You can't let THEM stay!"

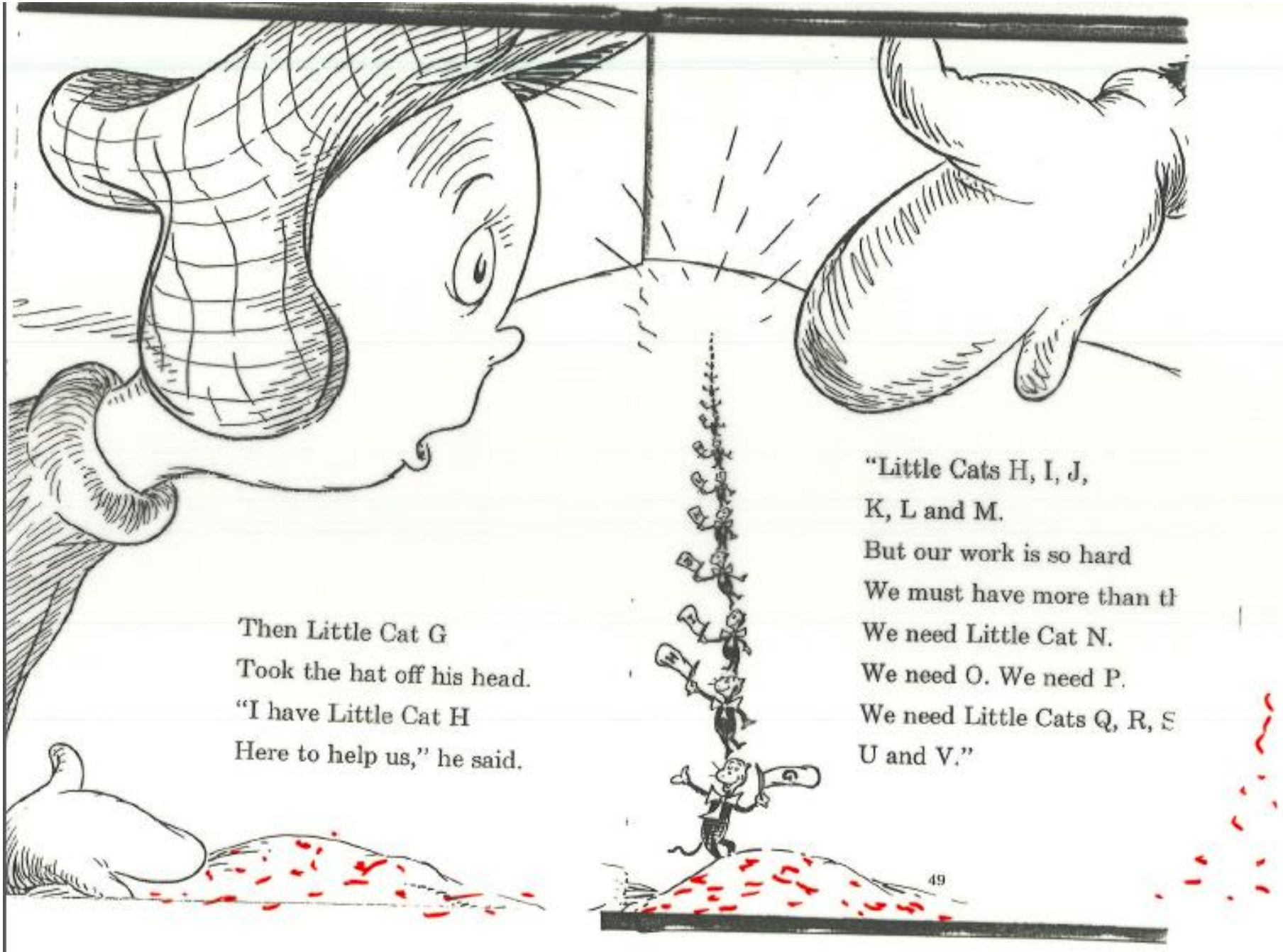
"Let us think about that now,"
Said C, B and A.



"With some help, we can do it!"
Said Little Cat C.
Then POP! On his head
We saw Little Cat D!
Then, POP! POP! POP!
Little Cats E, F and G!

"We will clean up that snow
If it takes us all day!
If it takes us all night,
We will clean it away!"
Said Little Cats G, F, E, D, C, B, A.

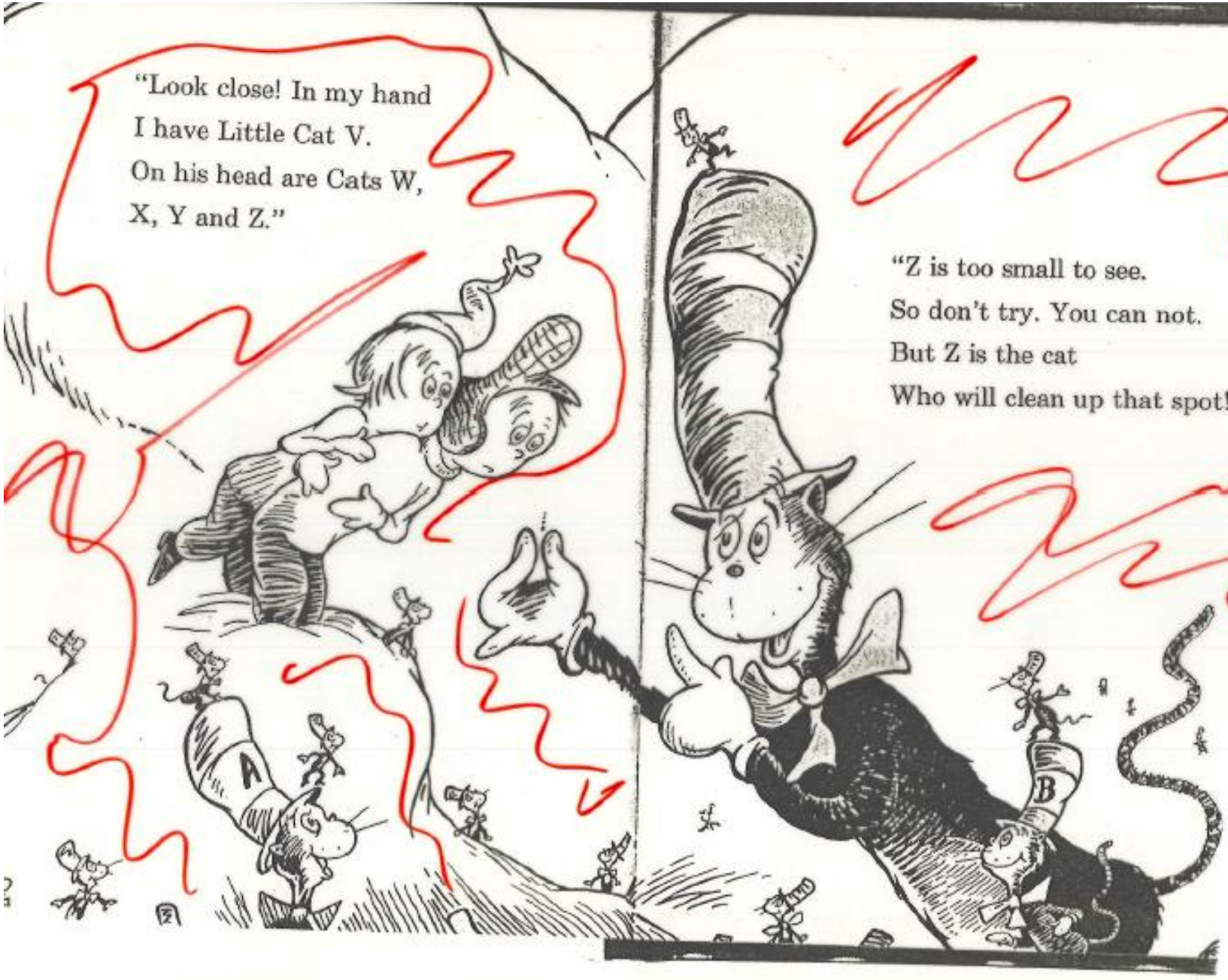




Then Little Cat G
Took the hat off his head.
"I have Little Cat H
Here to help us," he said.

"Little Cats H, I, J,
K, L and M.
But our work is so hard
We must have more than th
We need Little Cat N.
We need O. We need P.
We need Little Cats Q, R, S
U and V."

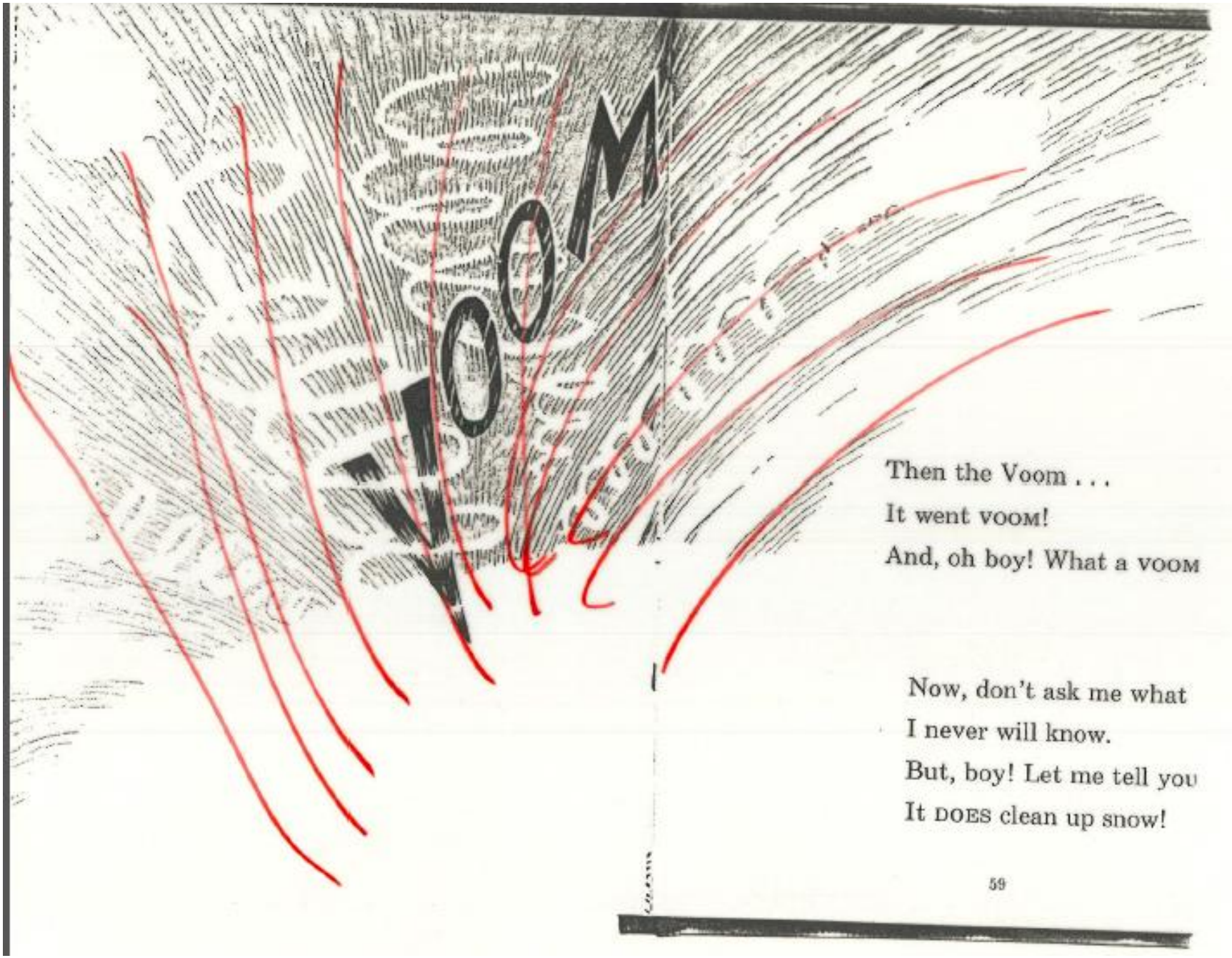
"Look close! In my hand
I have Little Cat V.
On his head are Cats W,
X, Y and Z."



"Z is too small to see.
So don't try. You can not.
But Z is the cat
Who will clean up that spot!"

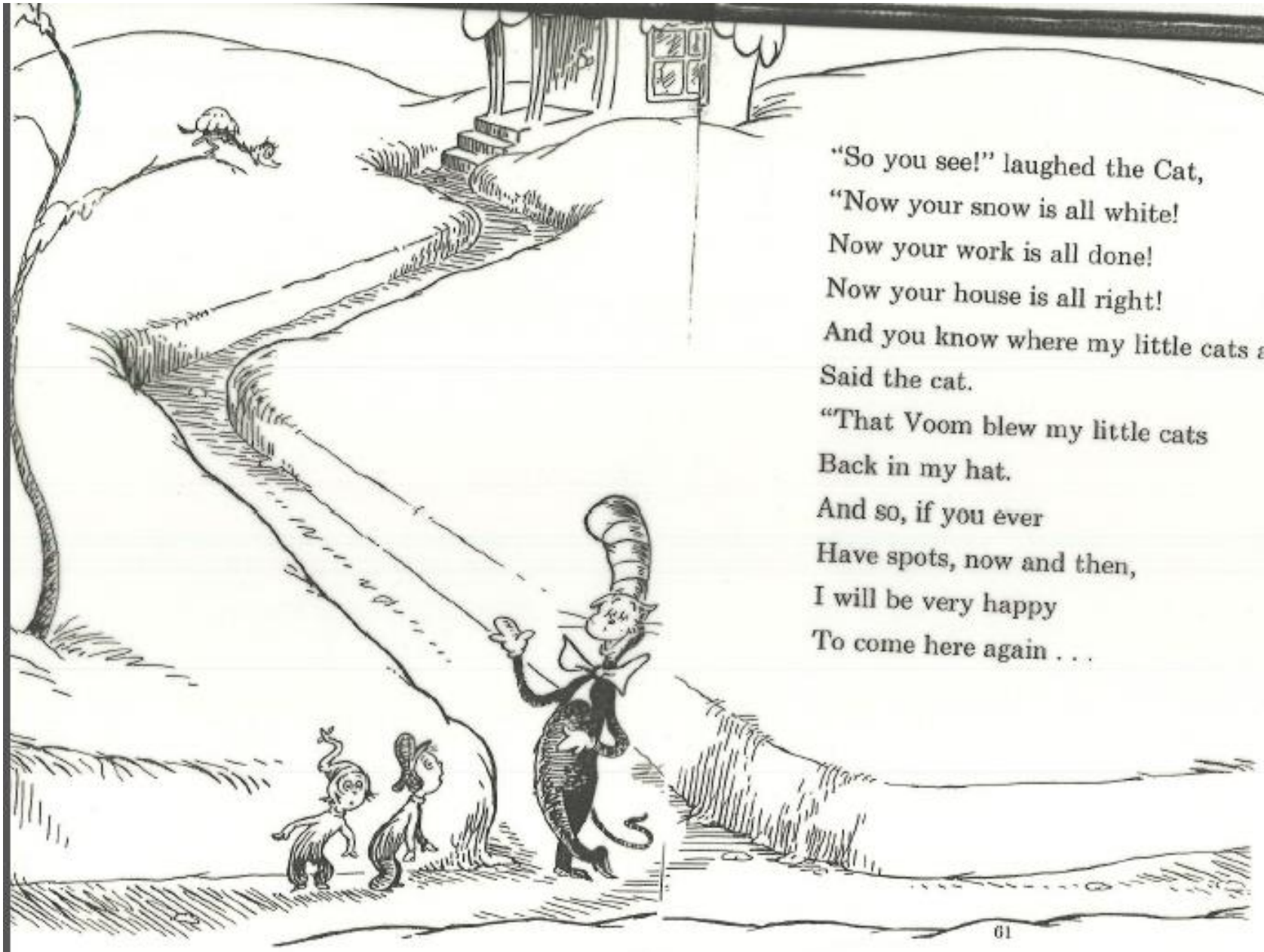
"Now here is the Z
You can't see," said the Cat.
"And I bet you can't guess
What he has in HIS hat!

"He has something called VOOM.
Voom is so hard to get,
You never saw anything
Like it, I bet.
Why, Voom cleans up anything
Clean as can be!"
Then he yelled,
"Take your hat off now,
Little Cat Z!
Take the Voom off your head!
Make it clean up the snow!
Hurry! You Little Cat!
One! Two! Three! GO!"



Then the Voom . . .
It went VOOM!
And, oh boy! What a VOOM

Now, don't ask me what
I never will know.
But, boy! Let me tell you
It DOES clean up snow!



"So you see!" laughed the Cat,
"Now your snow is all white!
Now your work is all done!
Now your house is all right!
And you know where my little cats a
Said the cat.
"That Voom blew my little cats
Back in my hat.
And so, if you ever
Have spots, now and then,
I will be very happy
To come here again . . .

". . . with Little Cats A, B, C, D . .

E, F, G . . .

H, I, J, K . . .

L, M, N . . .

and O, P . . .

. . . and Q, R, S, T . . .

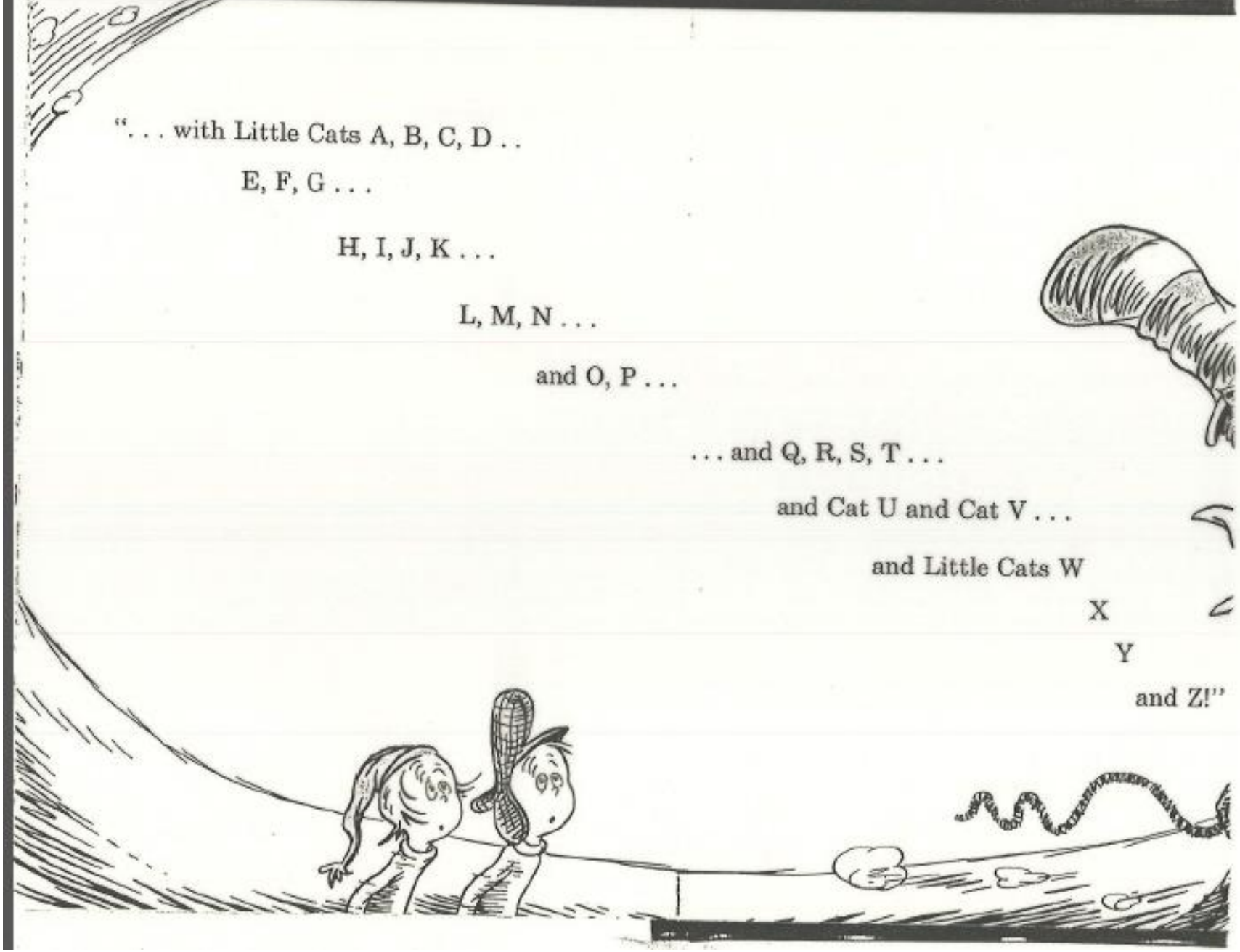
and Cat U and Cat V . . .

and Little Cats W

X

Y

and Z!"



Conclusions

- We have shown several ways to engage students with CS concepts and make those concepts come alive
- Questions?

- www.cs.duke.edu/~rodger