



Evaluation of games for teaching Computer Science

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Why games?

CS games

- Engagment
- Motivating
- Introductory for grade school
- Time on task
- CS Field Guide

More effective than:

- lectures
- reading
- videos
- assignments
- discussion
- combination of computerized tutorials and assignments
- the combination of lecture and instructional methods

**Sitzmann: meta-analysis
of 60 papers**

Less effective than:

- hands-on practice
- computerized tutorials
- the combination of group activities and discussion

- Better retention
- Better factual knowledge
- Better skill based knowledge
- Higher self-efficacy

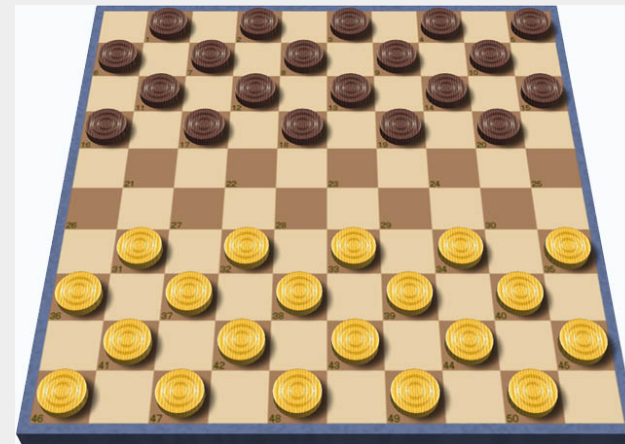
BUT!!

- Must be used with other instruction, especially debriefing

What is a game?

- Fun/free:
Light hearted, not obligatory, joyous
- Separate:
Circumscribed in time and space
- Uncertain:
Not pre-determined, player innovation

Roger Caillois (1913-1978)



<http://dratarrant.wordpress.com/>

What is a game?

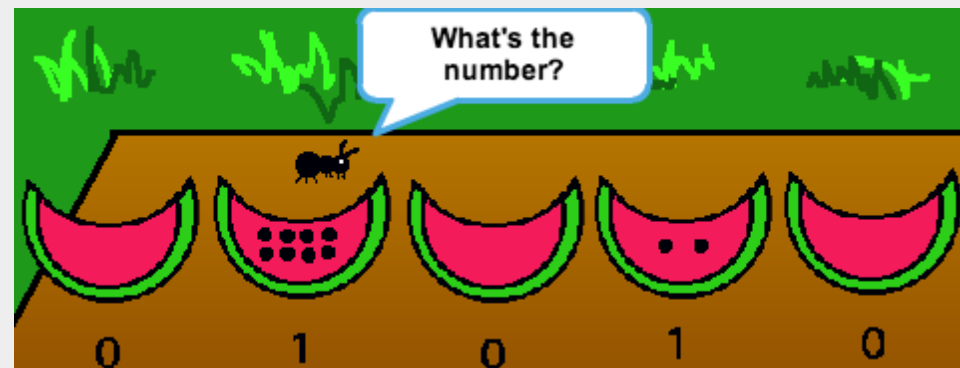
Roger Caillois (1913-1978)

- Rules:
 - New legislation which alone counts
- Make-believe:
 - Second reality or free unreality
- ~~Non-productive~~
Educational:
 - Teaches a CS topic:
 - better understanding
 - or skill



Continuum

- Obligatory play?
- Is binary make-believe?



- Replayability?

1 2 3 4 5 6

Show my number

New try

1	3	5	7	9	11	13	15
17	19	21	23	25	27	29	31
33	35	37	39	41	43	45	47
49	51	53	55	57	59	61	63
2	3	6	7	10	11	14	15
18	19	22	23	26	27	30	31
34	35	38	39	42	43	46	47
50	51	54	55	58	59	62	63
4	5	6	7	12	13	14	15
20	21	22	23	28	29	30	31
36	37	38	39	44	45	46	47
52	53	54	55	60	61	62	63
16	17	18	19	20	21	22	23
24	25	26	27	28	29	30	31
48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63
32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55
56	57	58	59	60	61	62	63

Your number is: 24

Wolfram Demonstrations Project

demonstrations.wolfram.com

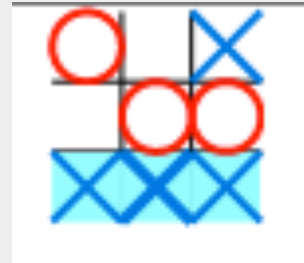
Finding games

CS games

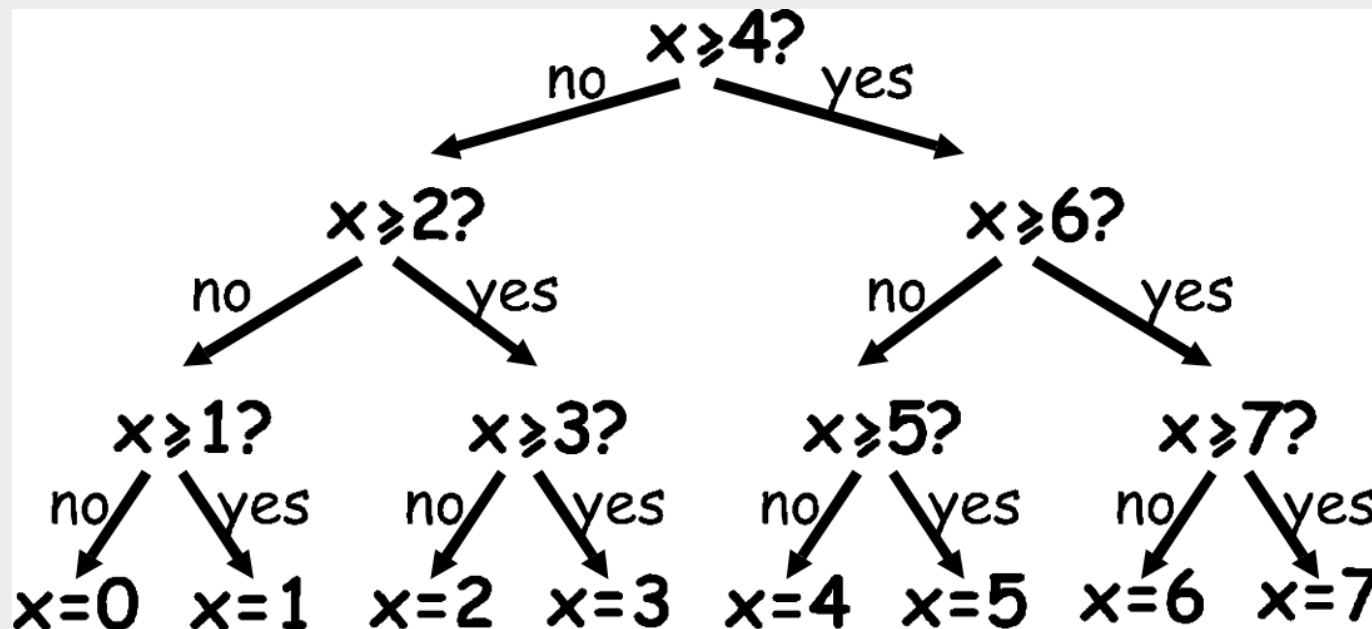
- CS ed papers
- CS teaching resource repositories
- Search
- Post list on SIGCSE mailing list
- 81 potential games
 - 13 not CS
 - 18 not games
 - 9 unavailable
 - 41 in final list

Useful, but concept not in game

- Noughts and crosses (AI)
- Twenty questions (Information theory)

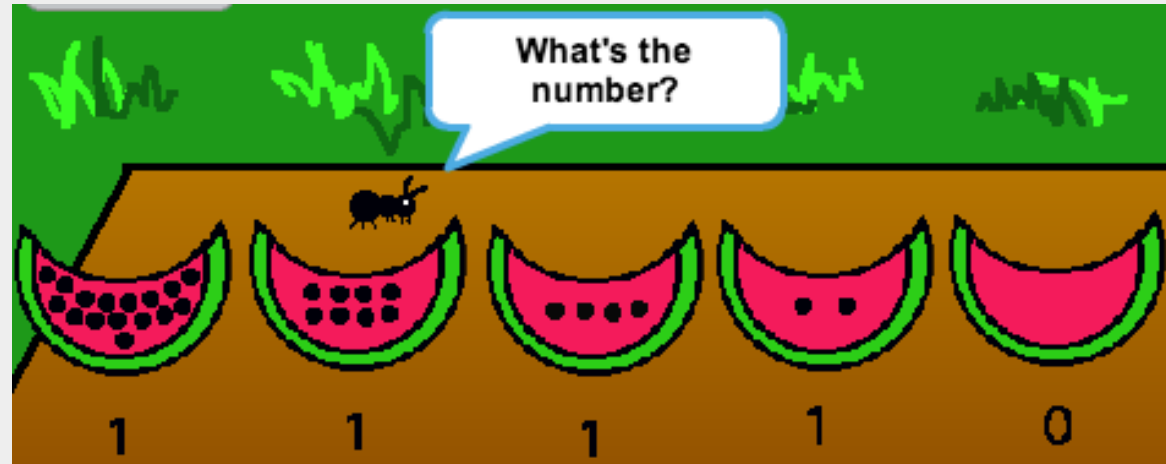


CS games

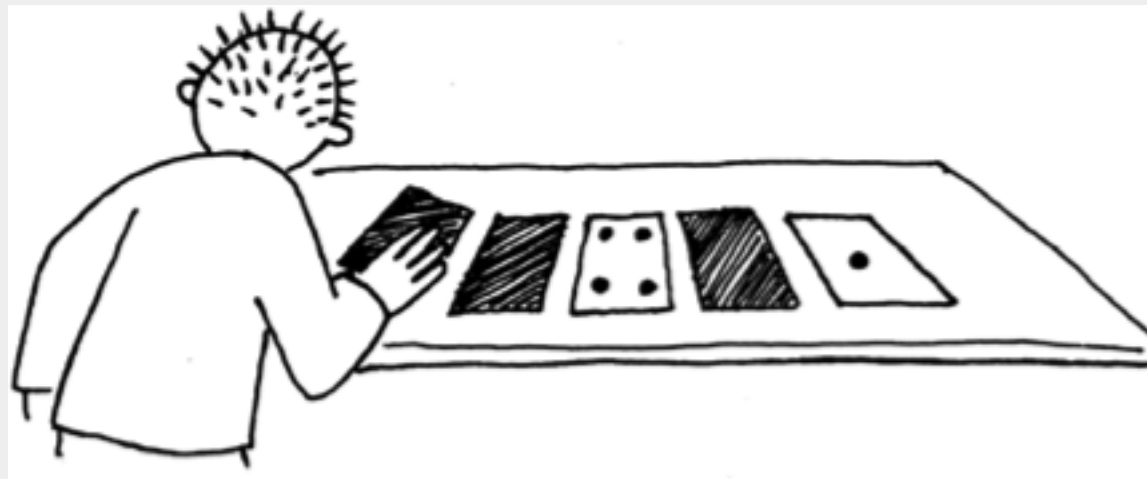


Sitzmann and Callois

- Game



- Not a game



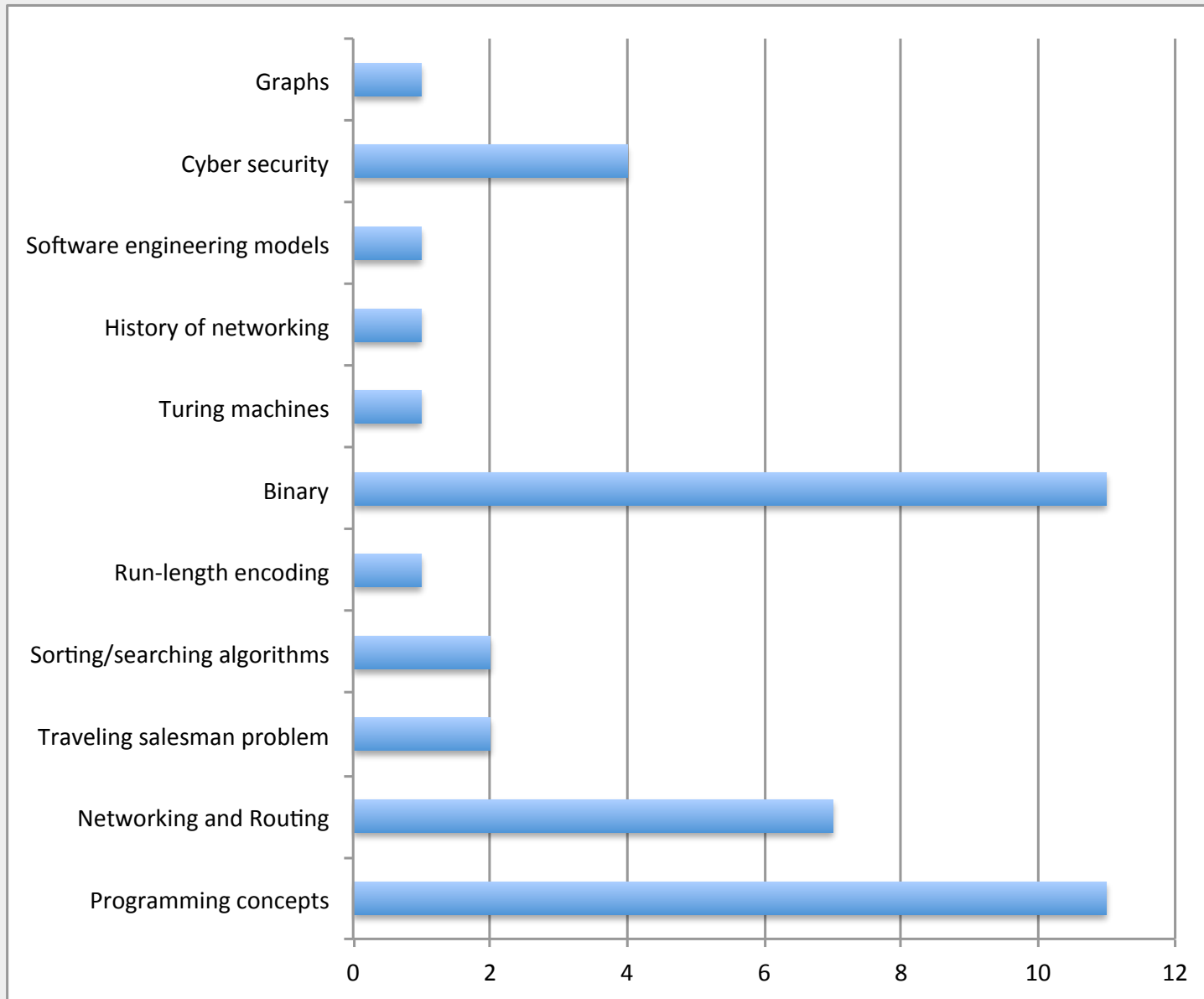
Types of games found

CS games

	Cost			Hours required		
	Free	Low	High	$< \frac{1}{2}$	$\frac{1}{2}$ to 2	> 2
Desktop	4	0	1	0	0	5
Mobile	1	3	0	4	0	0
Browser	21	0	0	21	0	0
Unplugged	9	0	2	6	5	0

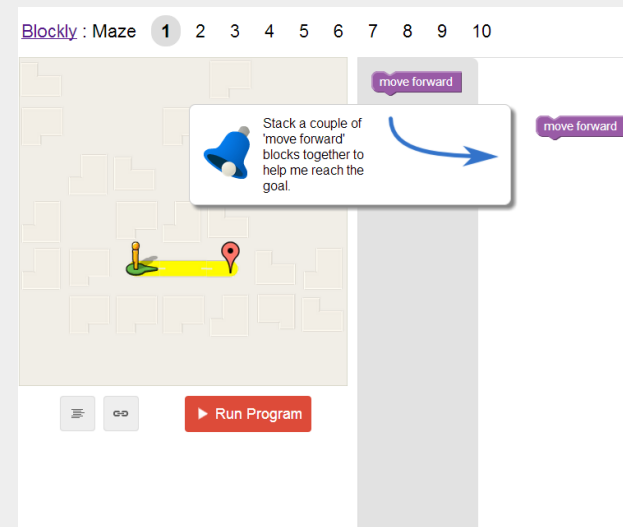
Topics covered

CS games



Programming concepts

- ToonTalk 3
- Cargo bot
- The Bead Loom game
- Blockly
- Brando the Egg Hunter
- Lightbot
- Lightbot 2.0
- RoboZZle
- Treasure Hunter
- Swap puzzle



RoboRally

CS games



Programming concepts

- Instruction sequence
- Functions
- Design/planning
- Conditionals
- Loops

Light bot

CS games

Rotate the Bot with these.

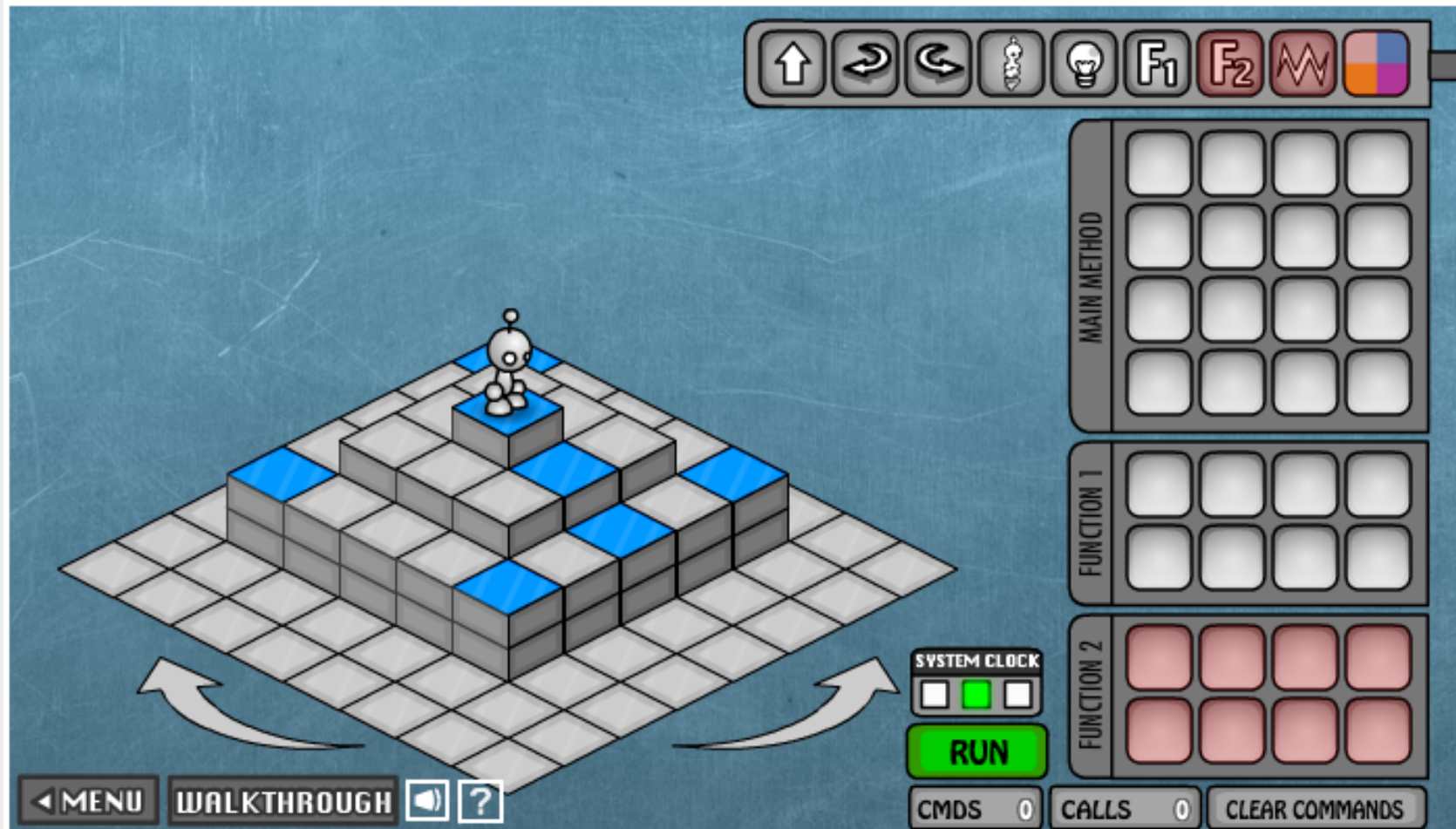
↑	↻	↺	👤	💡	f ₁	f ₂
MAIN METHOD						
FUNCT. 1						
FUNCT. 2						
Total Commands						3

RESET More Games

GO!

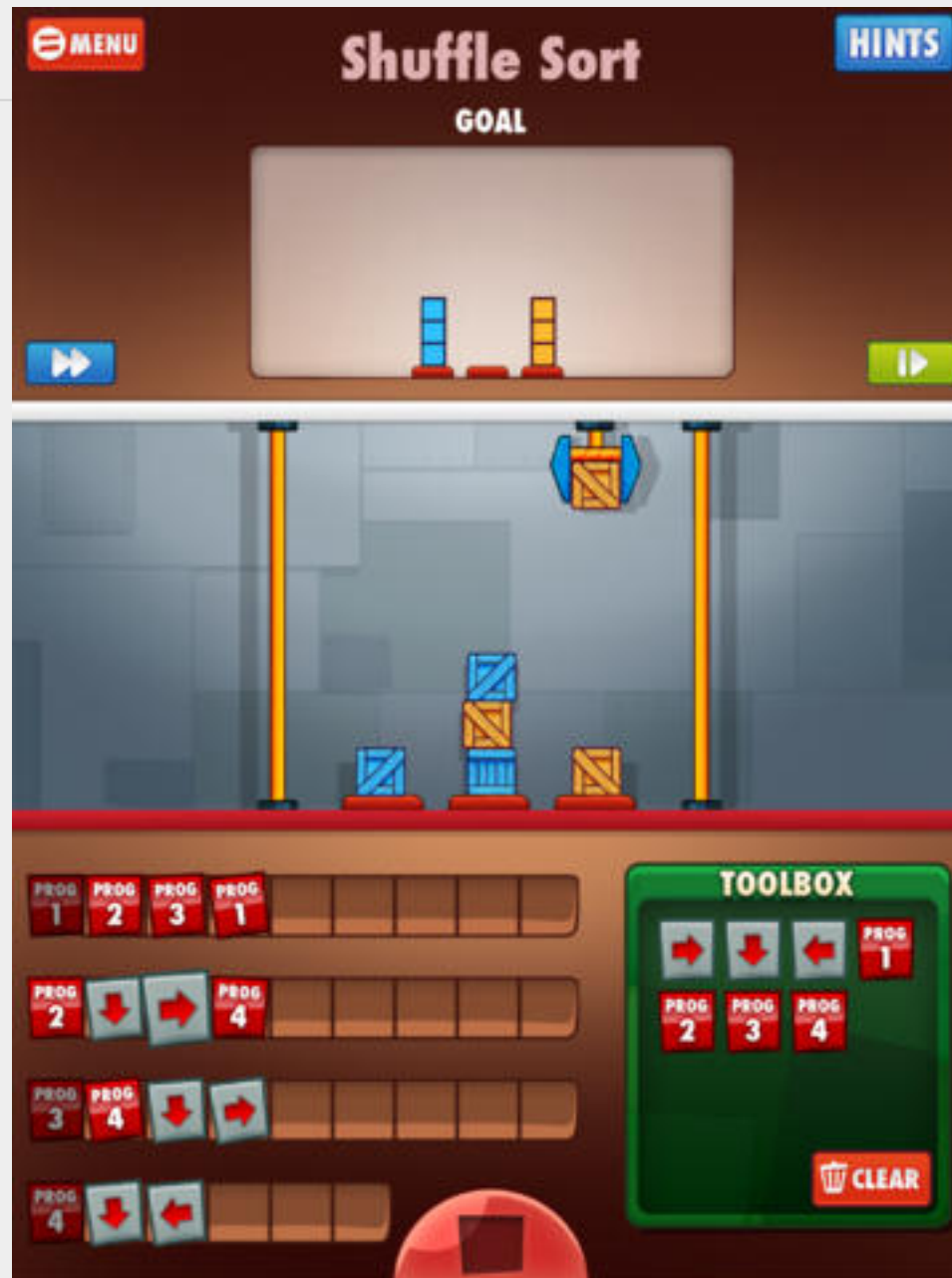
Lightbot 2 (recursion)

CS games



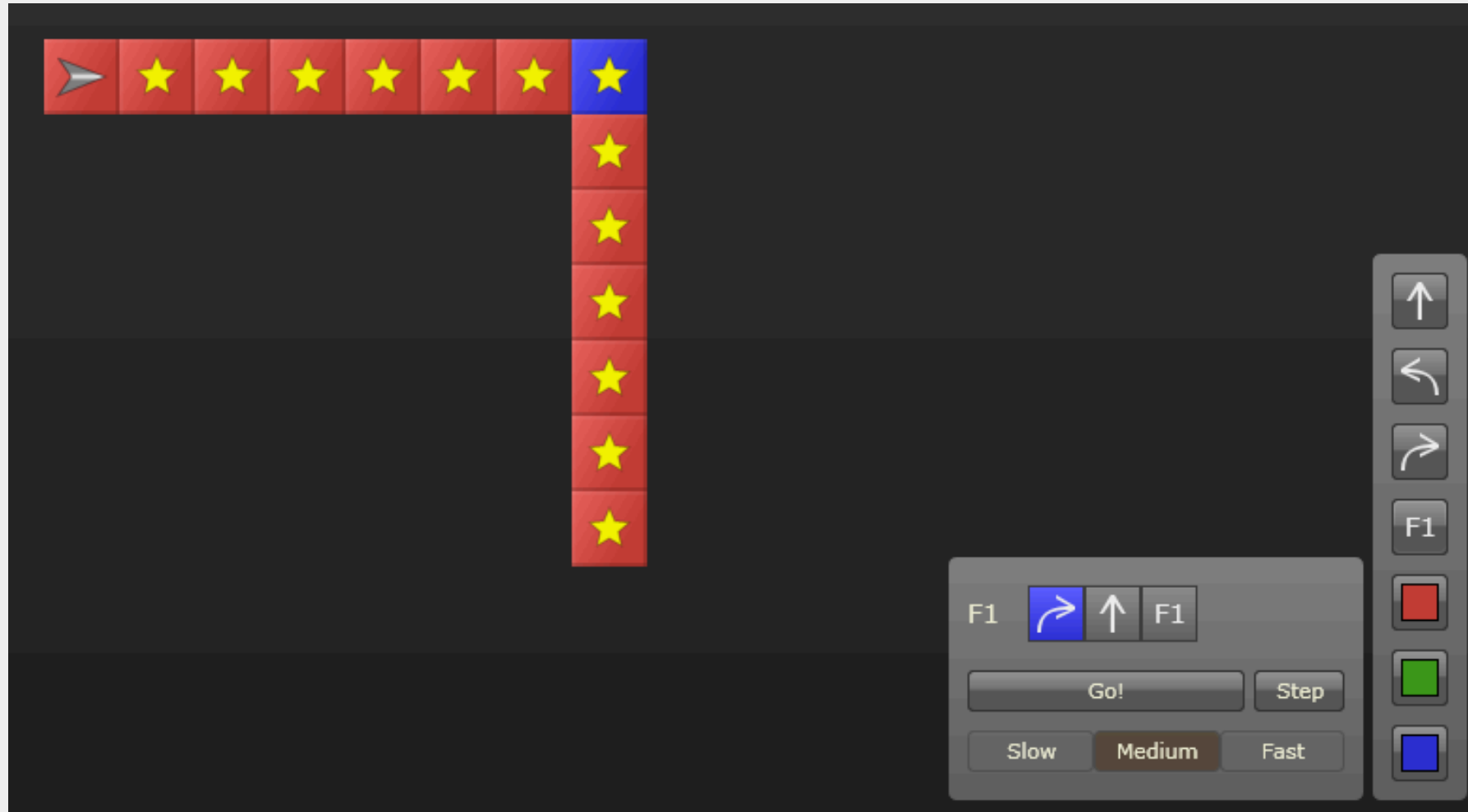
Cargobot

CS games



RoboZZle (recursion)

CS games



Cisco Binary

CS games

BINARY

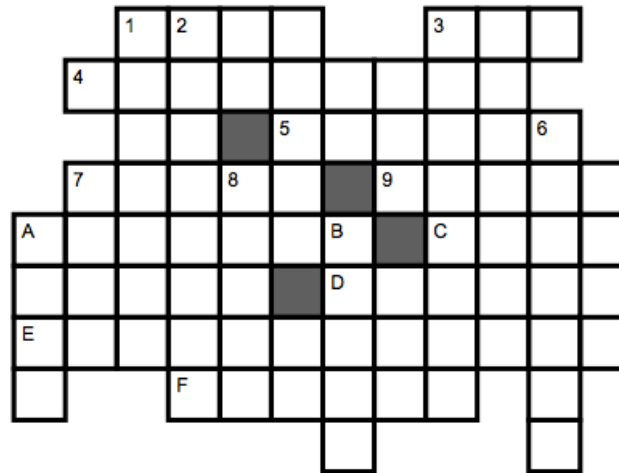
128	64	32	16	8	4	2	1		
0	0	0	0	0	0	1	0	=	
0	0	0	0	1	1	1	1	=	0
0	0	0	1	0	0	0	0	=	
0	0	0	0	1	0	0	1	=	0
0	1	0	0	0	0	0	1	=	31
0	0	0	0	0	0	1	0	=	8

Score 200
Level 1
Lines Left 13

|| Pause game
🔊 Music Off
⏪ Change Music ⏩
✕ End Game

Crossbin

Crossbin #1



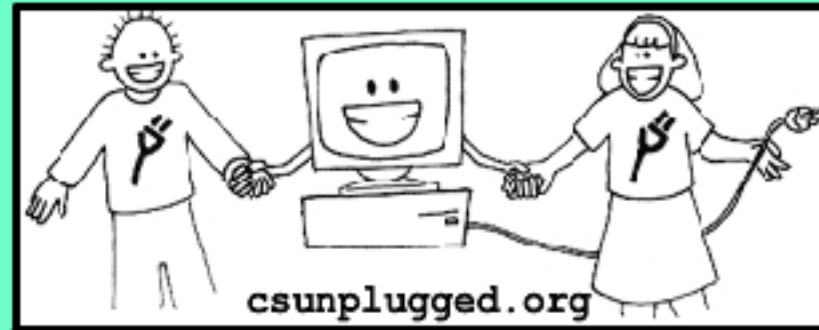
Across

- [1]: 8
- [3]: 4
- [4]: 44
- [5]: 3C
- [7]: 1B
- [9]: C
- [A]: 7F
- [C]: E
- [D]: 1D
- [E]: A0A
- [F]: 36

Down

- [1]: 5F
- [2]: 6D
- [3]: BE
- [6]: 1C
- [7]: C
- [8]: 1D
- [A]: E
- [B]: 1A

Binary Flash



Convert to decimal

Convert the binary number "0 0 1 1 1 1" to decimal,
you may use the columns to help you.

32		16		8		4		2		1
0		0		1		1		1		1

Answer:

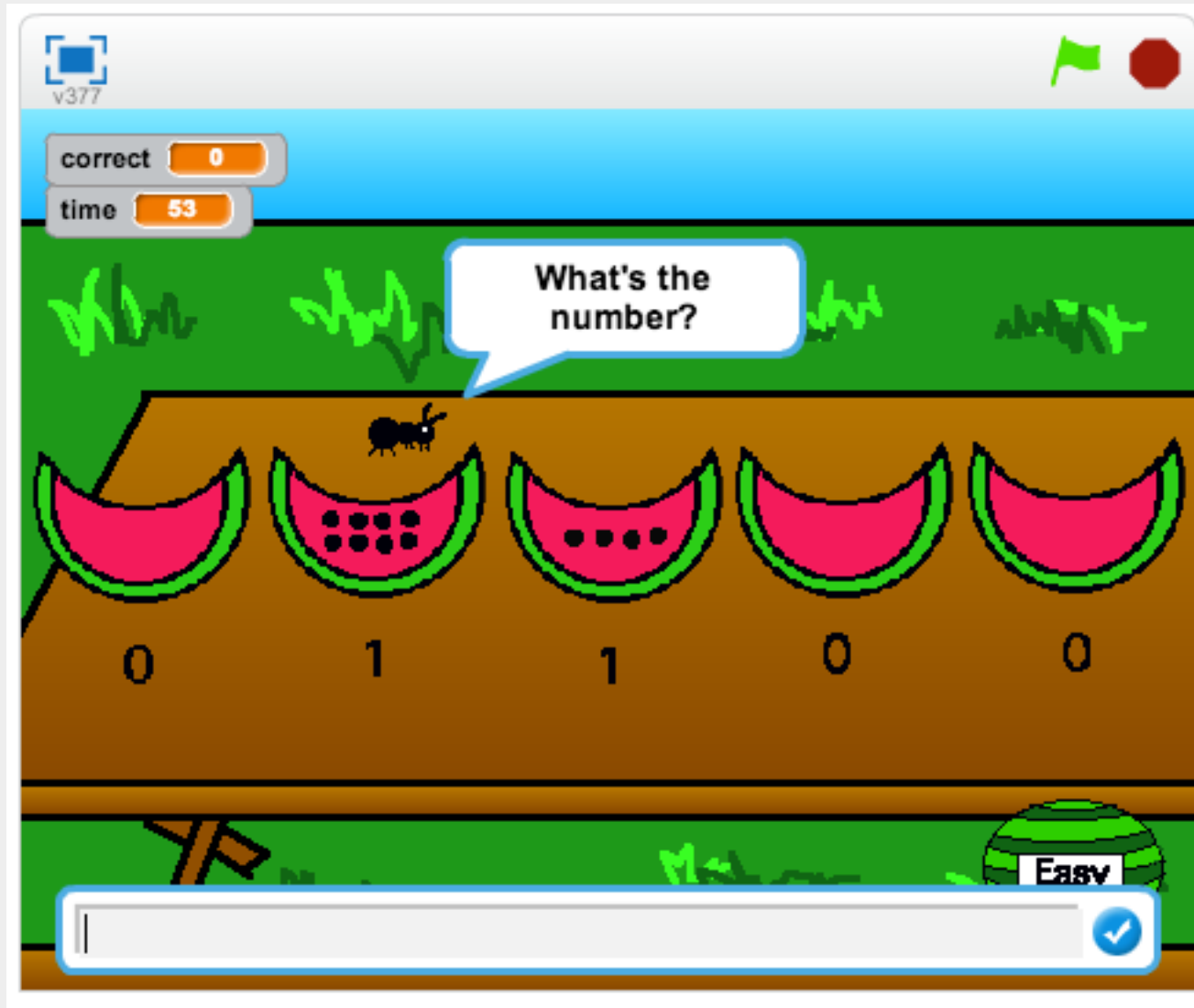
(10 left to go)

**Submit
Answer**

<< MAIN MENU

Binary number quiz

CS games



Binary fun

CS games

B I N A R Y F U N

128 64 32 16 8 4 2 1

1 0 0 1 0 0 0 0

written by jerry wolski

144

Round 1

NEW GAME

START ROUND

STOP GAME

ABOUT

GO
press space

149
DECIMAL

TIMER

Binary flash cards

CS games

Correct **0** Incorrect **0**

1 1 1 1 1 1 0 1

EXAMPLE **HELP**

What is the base 10 equivalent?

Cross-binary app

CS games

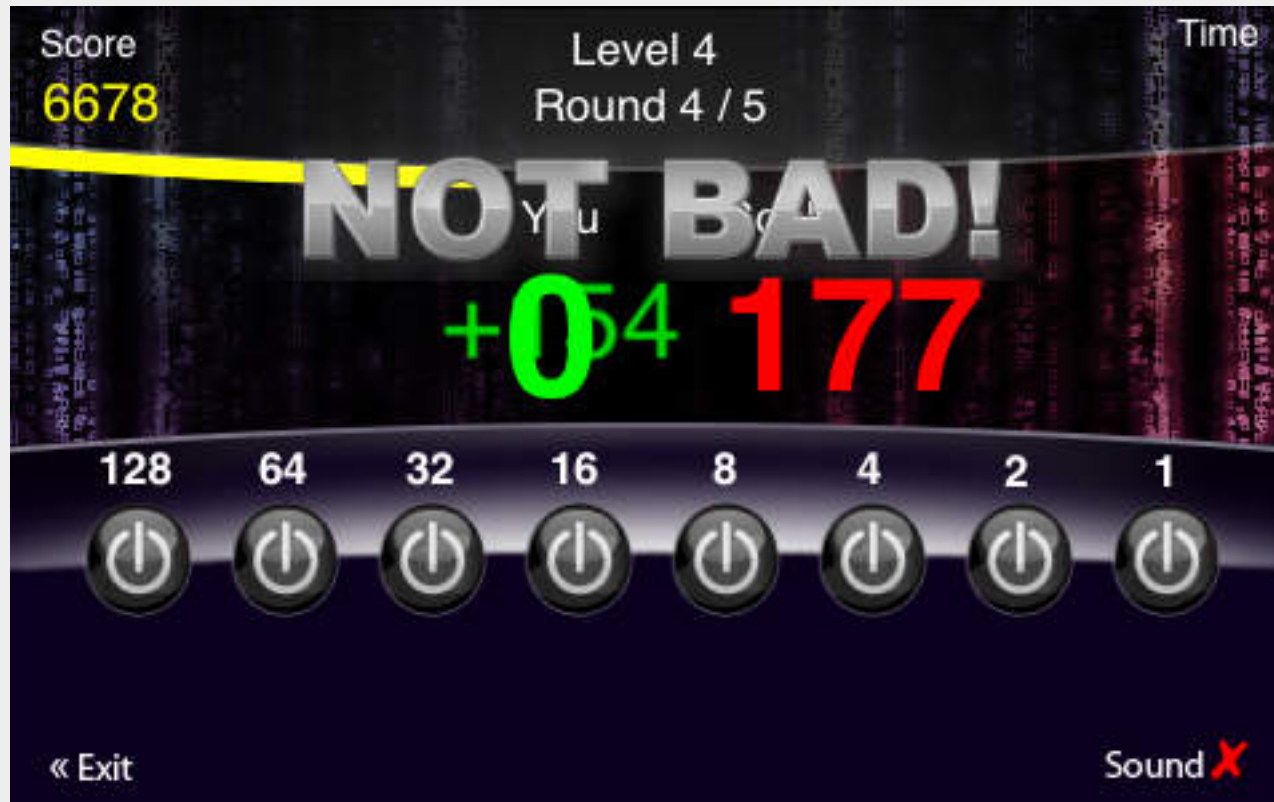
The screenshot displays a Cross-binary app interface. At the top, a row of eight colored boxes contains the binary sequence 0 0 1 0 1 1 0 1, with a score of 45 to the right. Below this is a row of powers of two: 128, 64, 32, 16, 8, 4, 2, 1. The main area shows a grid of binary digits (0s and 1s) on a dark background with a starry pattern. The grid is 8 columns wide and 10 rows high. The digits are arranged as follows:

1		1		1		1			
							0		
	1		0		1		1		
							1		
	0	0	1	0	0	1	0	1	
							1		
	1		0		0		0		
								0	

At the top of the grid, there are four boxes labeled 'Across' with values 14, 45 (highlighted in green with a checkmark), 80, and 109. Below them are four boxes labeled 'or Up' with values 152, 194, 211, and 245. To the right of these boxes is a 'Time:' label and a timer showing '02:08'. At the bottom of the screen, there is a navigation bar with four icons: a floppy disk labeled 'Save', a broom labeled 'Clear', a lightbulb labeled '16 hints', and a door labeled 'Exit'.

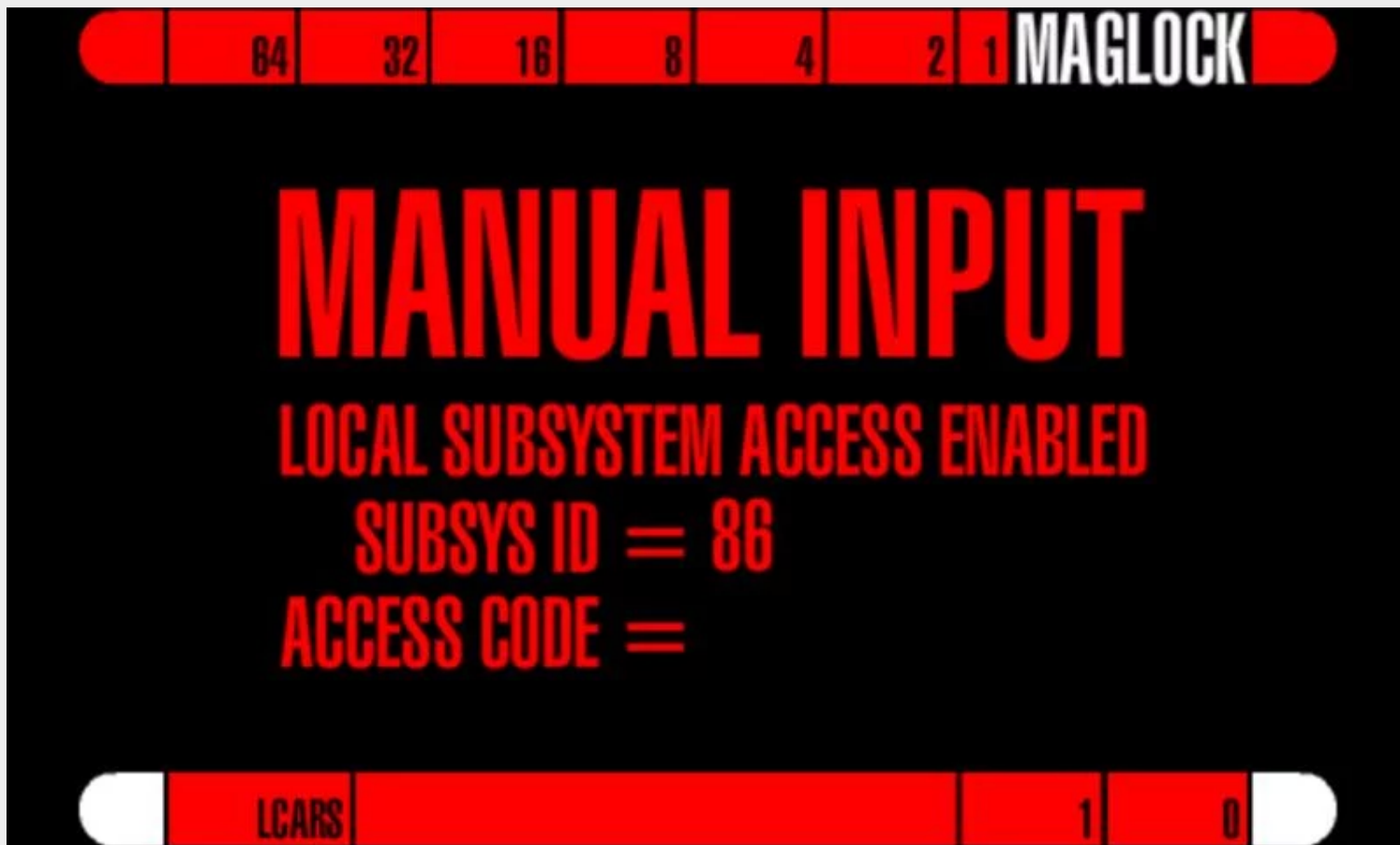
Binary game

CS games



Binary Maglock

CS games

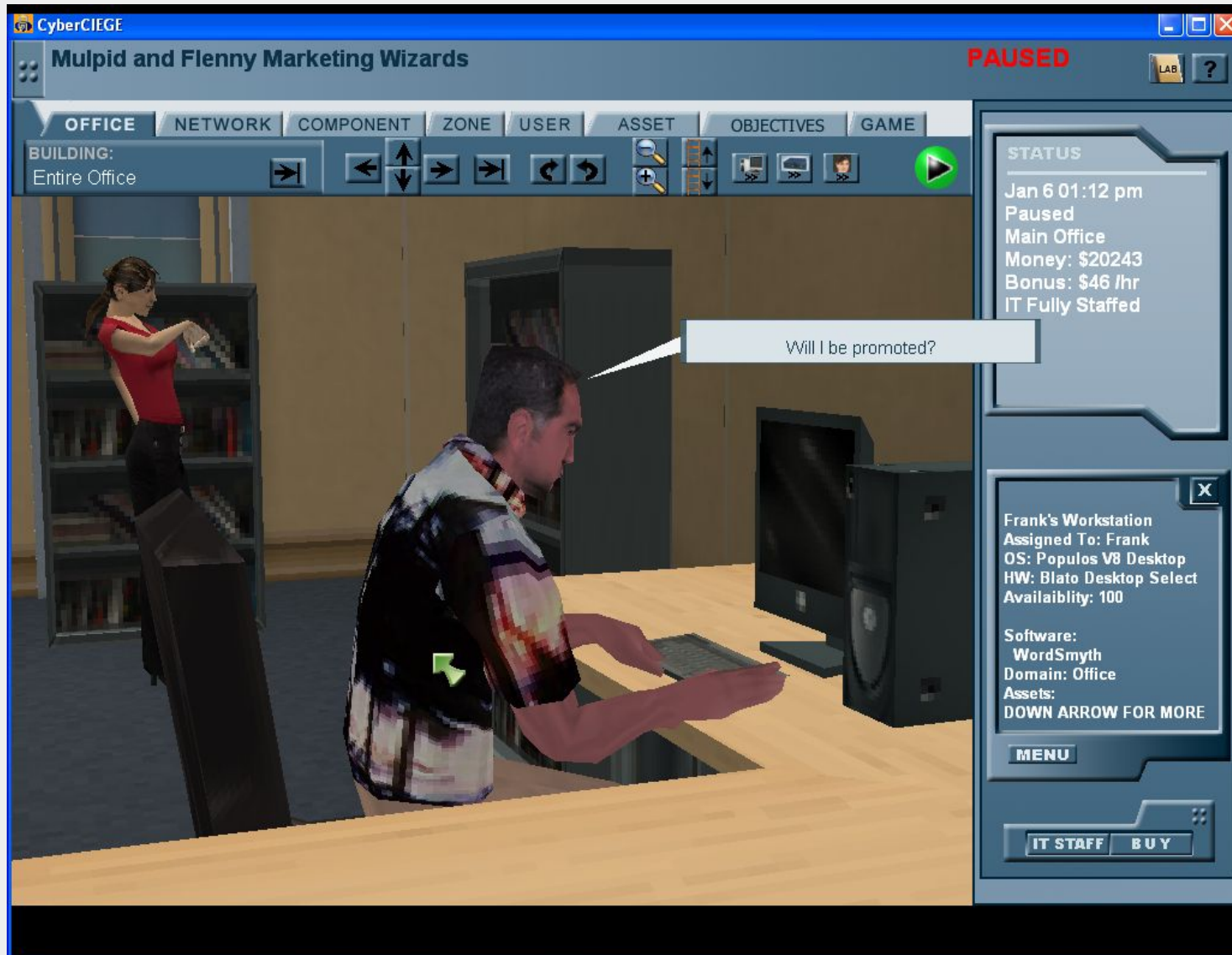


Binary principles

- Conversion?
- Or...
 - Each bit doubles range
 - Adding 1
 - Double a number
 - 8/16/24/32/64 bits
 - 200/1000 bit crypto
 - Arithmetic and logic

CyberCIEGE (security)

CS games



myPlanNet (history of networking)

CS games

The screenshot displays the myPlanNet game interface. At the top left is the Cisco logo and the game title 'myPlanNet'. The current era is 'MediaNet Era' and the date is 'Apr 2003'. There are three buttons labeled 'DU', 'BB', and 'MC'. A 'Next Goals' section shows a 'Researching' status with a smiley face icon and a progress bar.

On the left side, there are statistics:

- Available Cash: 288,583,000
- Monthly Income: 62,947,400
- Customers: 3,693,310

On the right side, there are more statistics:

- Business Happiness: 11,642,800
- Resident Happiness: 13,501,200
- Businesses: 3,764
- Residents: 336,848

The central part of the screen shows a 3D isometric view of a city grid with various buildings, roads, and green spaces. A yellow smiley face icon is visible on the grid.

At the bottom, there is a navigation bar with buttons for: Main Menu, Connect Citizens, Network Operations, Service Operations, Research, Game Information, Map, Status, and Tutorial.

Orange game

CS games



Mind Share (networking and binary)

CS games

The screenshot displays the 'ESA Wireless Topology' puzzle in the Cisco Mind Share game. At the top, the Cisco logo is on the left, and the game status shows 'Wireless', '2x' multiplier, '150' score, 'ROUND 14 STAGE 31 HARD', and '1235' points. The puzzle area is divided into three sections: a text box on the left, a central diagram, and two bottom diagrams.

ESA Wireless Topology

If a single cell does not provide enough coverage, any number of cells can be added to extend the range. It is recommended that ESA cells have 10 to 15 percent overlap to allow remote users to roam without losing RF connections. Bordering cells should be set to different, non-overlapping **channels** for best performance.

Drag a wireless **Access Point** from the Stream and drop it in the QBOX closest to the laptops; try to include all of the laptops in as few cells as possible. Make sure that cells with the same channel don't overlap.

The central diagram shows a network topology with a central router connected to the Internet, a switch, and several laptops. The bottom diagrams show the player's progress, with some cells containing question marks and others containing the number '11'. A 'Quit' button is on the bottom left and an 'Options' button is on the bottom right.

[d0x3d!]

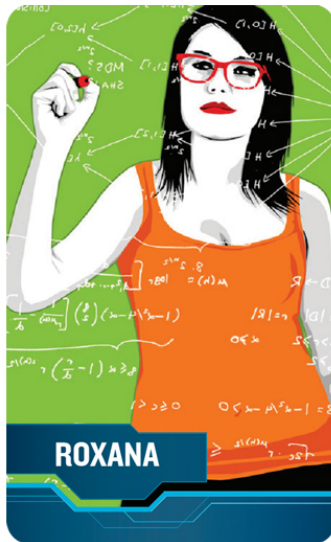
a network security game

CS games



CTRL-ALT-HACK

CS games



ROXANA

11 HARDWARE HACKING	11 SOFTWARE WIZARDRY
11 NETWORK NINJA	14 CRYPTANALYSIS
10 SOCIAL ENGINEERING	9 KITCHEN SINK

By discarding two cards from her hand, she can substitute her Cryptanalysis skill for either Hardware Hacking or Social Engineering. This substitution only applies to one task.

A big fan of elegant math and detective stories, Roxana's always more than happy to turn any problem into a math puzzle.

CONTROL-ALT-HACK

MISSION

One Hacker, Won Vote

The audit target: an electronic voting machine rushed to market in time for an election.

LOCKPICKING OR WEB PROCUREMENT
Pick the lock or locate a site that sells the manufacturer's master key. Now you have access to the system internals—including the software.

SOFTWARE WIZARDRY
Use your reverse engineering skills to discover ways to undetectably change votes.

Success: +1 Hacker Cred. You could pull this attack off in two minutes in a voting booth.

Failure: -1 Hacker Cred

CONTROL-ALT-HACK

BAG OF TRICKS

Dumpster Diving

You don't mind getting dirty. You're happy to dig through a company's garbage to look for un-shredded specs, documentation, and inter-office memos. This time the client's guards are vigilant. Rent a garbage truck, then go through your haul off-site.

Play this card during a Mission. All your Hardware Hacking rolls for the Mission are automatic successes.

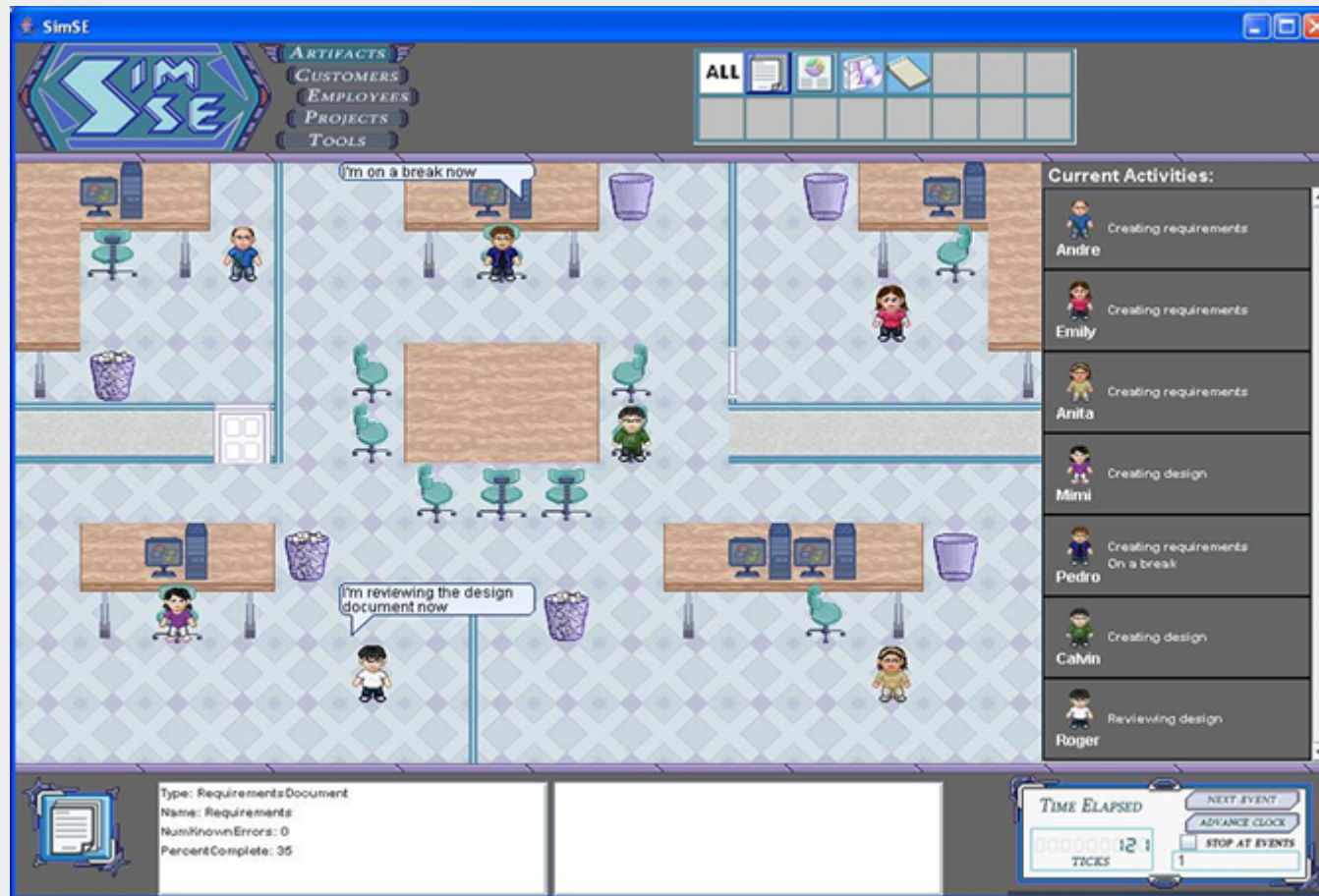
Discard this card after use.

Cost: \$4K


CONTROL-ALT-HACK

SimSE (Software Engineering)

CS games



Tour finder

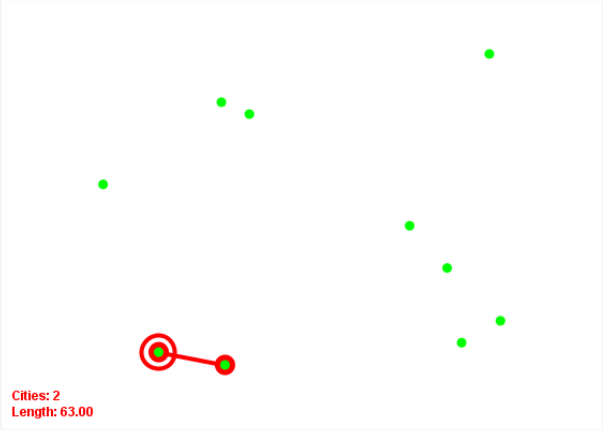
TSP 

TSP Games > Tour Finder

Home
TSP Games
> Tour Finder
Tour Race

Tour Finder

The object of this game is to find the shortest possible **traveling salesman tour** through the green cities. The tour may start off at any of the cities, must touch upon each city at least once, and return to the originating city. It is fairly easy to find a good tour. Finding the best possible roundtrip is far less obvious.



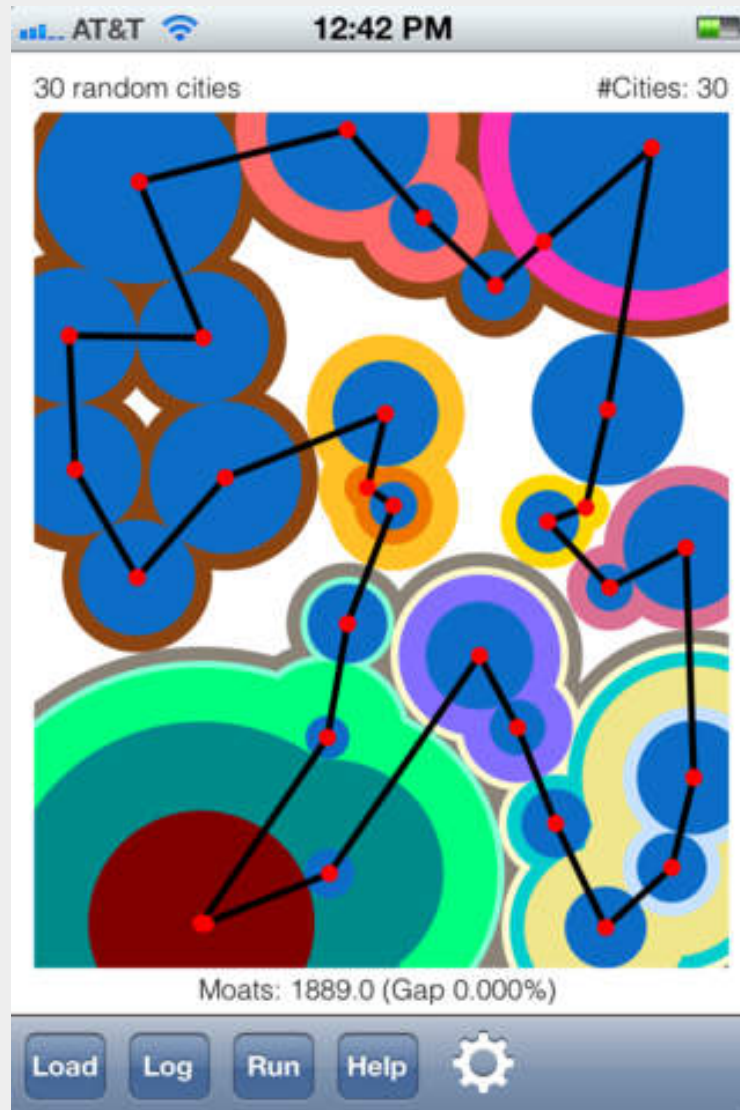
Cities: 2
Length: 63.00

- Define a traveling salesman tour by clicking your left mouse button on circles.
- Type the letter 'x' to undo your last choice.
- Type SPACE to start on a new problem of the same size.
- Type '+' or '-' to start on bigger or smaller problem.
- Once you define a complete tour you see how it compares to the optimal tour. If your tour is the best possible in terms of its length type SPACE to try your hand at another problem. In the more likely case that your tour is not optimal you have the following choices:
 - Type 'o' (for optimal) and the applet shows you the optimal tour along with your tour. You can type 'f' to change the display mode or SPACE to return to editing your tour.
 - Type 'x' to remove the last city from your tour. This returns the game into editing mode. After removing a few cities you can try to build a better tour.
 - Type SPACE if you want to start over with a new problem

These games was implemented using the mcmTheater package, see [mcmTheater Home](#).

Concorde TSP

CS games



Game evaluation

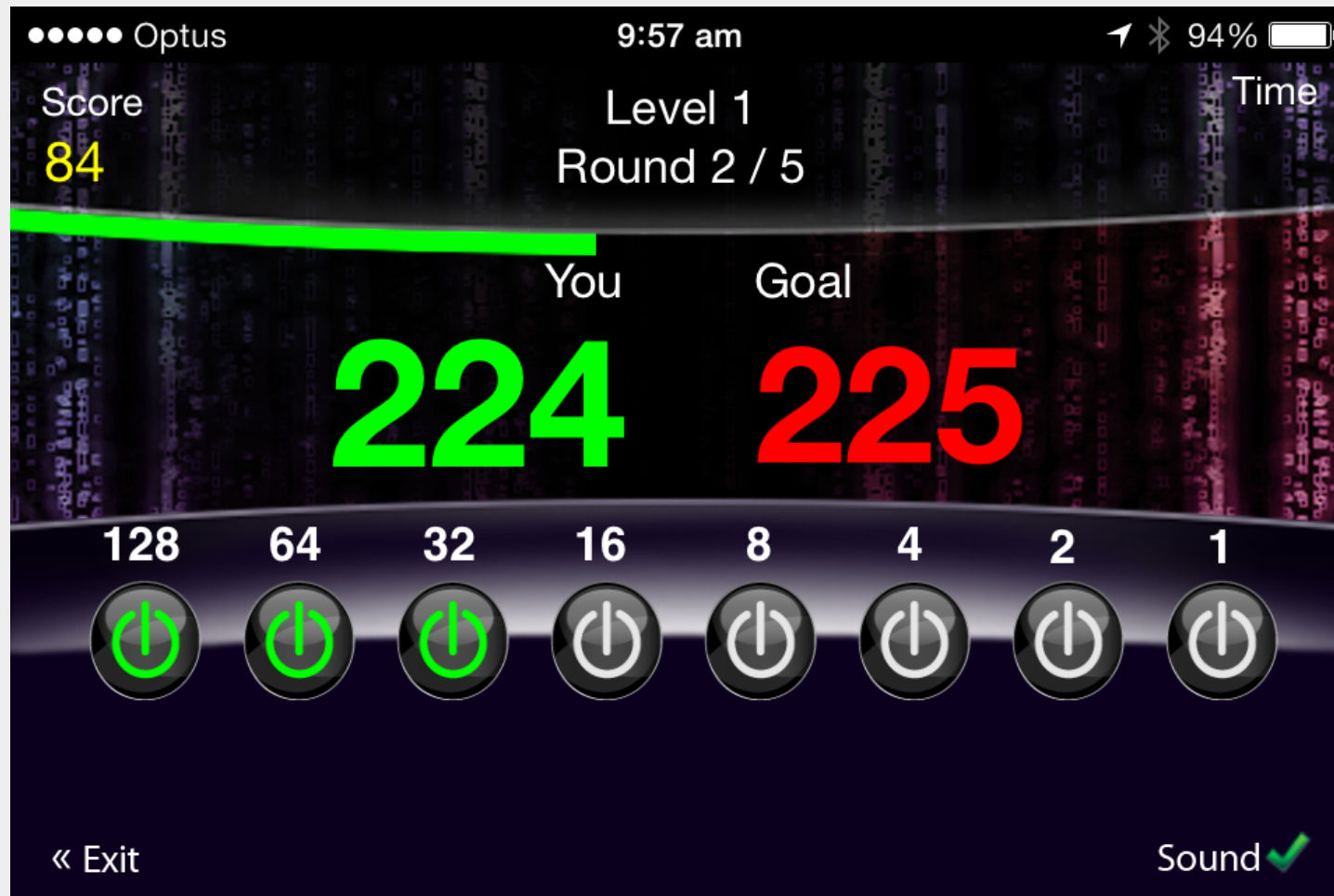
- Active/Passive
- Flow
- Longevity

Active/passive

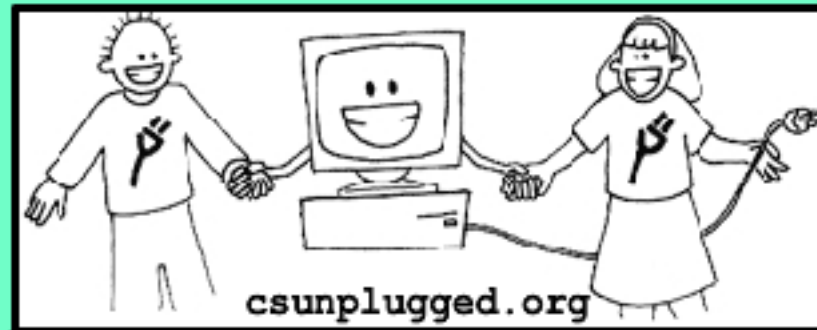
- Active: Educational content is part of game
- Passive: Content is in instructions or support material

Binary game

CS games



CS Unplugged Binary Flash



How do you do it?

With binary numbers, the right most number is worth the least and the left most worth the most and each column is worth double the one on it's right e.g.

256|128|64|32|16|8|4|2|1

if there is a "1" in the column you add that value to the total, if there is a "0" you don't

<< PREVIOUS

CONTINUE >>

Blockly level 1

[Blockly](#) : Maze

1

2

3

4

5

6

7

8

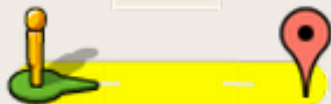
9

10

move forward



Stack a couple of 'move forward' blocks together to help me reach the goal.



Blockly level 5

CS games

[Blockly](#) : Maze

1

2

3

4

5

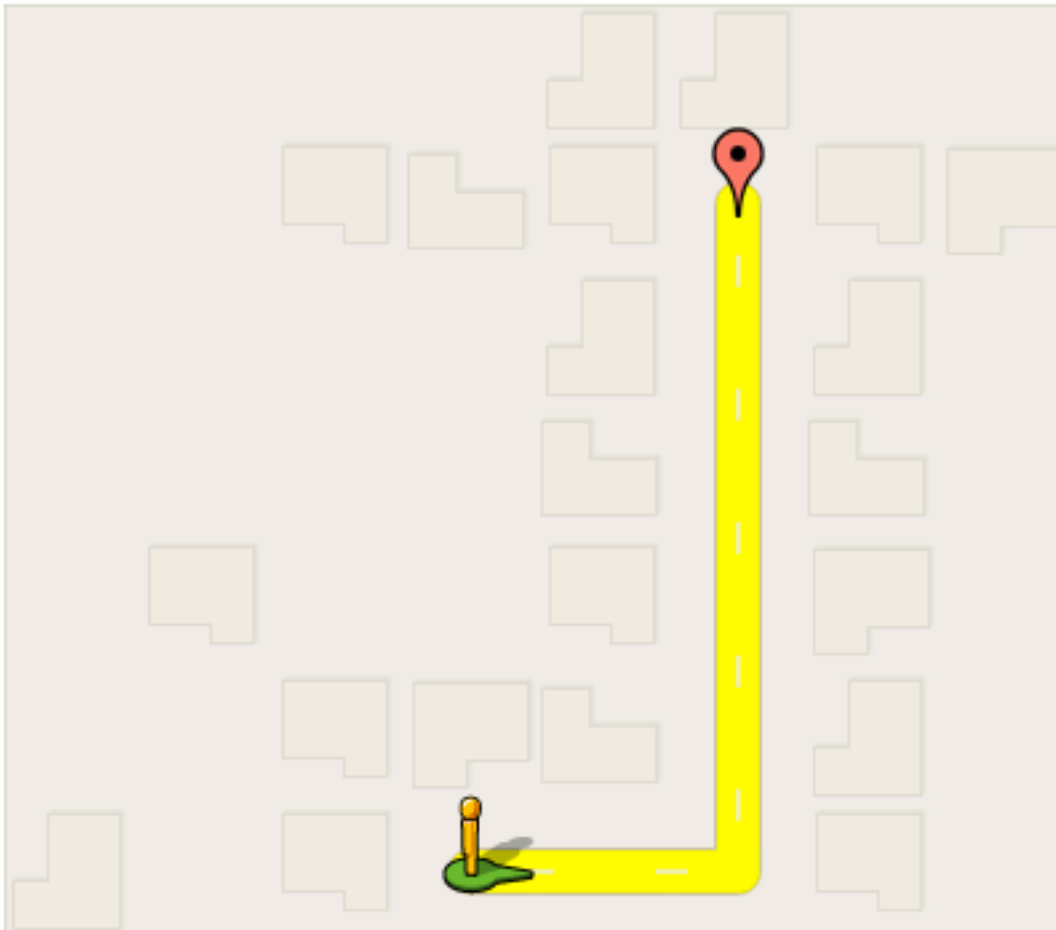
6

7

8

9


10



move forward

turn left ↻

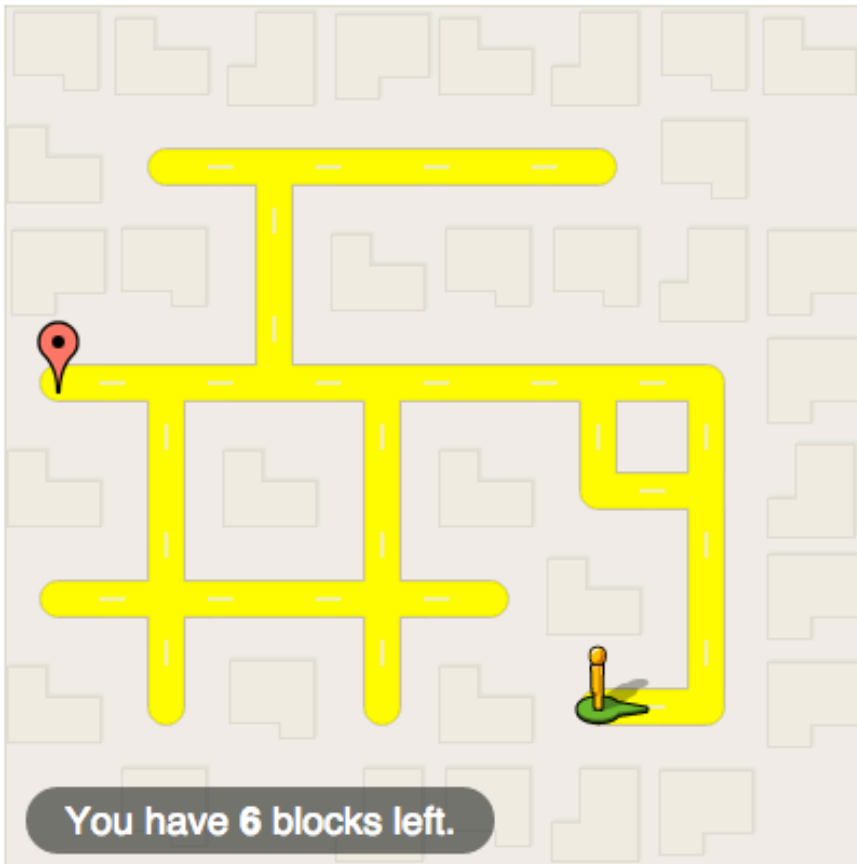
turn right ↻

repeat until 
do

Blockly level 9

CS games

[Blockly : Maze](#) 1 2 3 4 5 6 7 8 **9** 10



A maze game interface. A yellow path is drawn on a grid. A red pin marks the start, and a green robot is at the end of the path. A grey box at the bottom says "You have 6 blocks left."



▶ Run Program

move forward

turn left ↺

turn right ↻

repeat until 📍

do

move forward



If-else blocks will do one thing or the other.



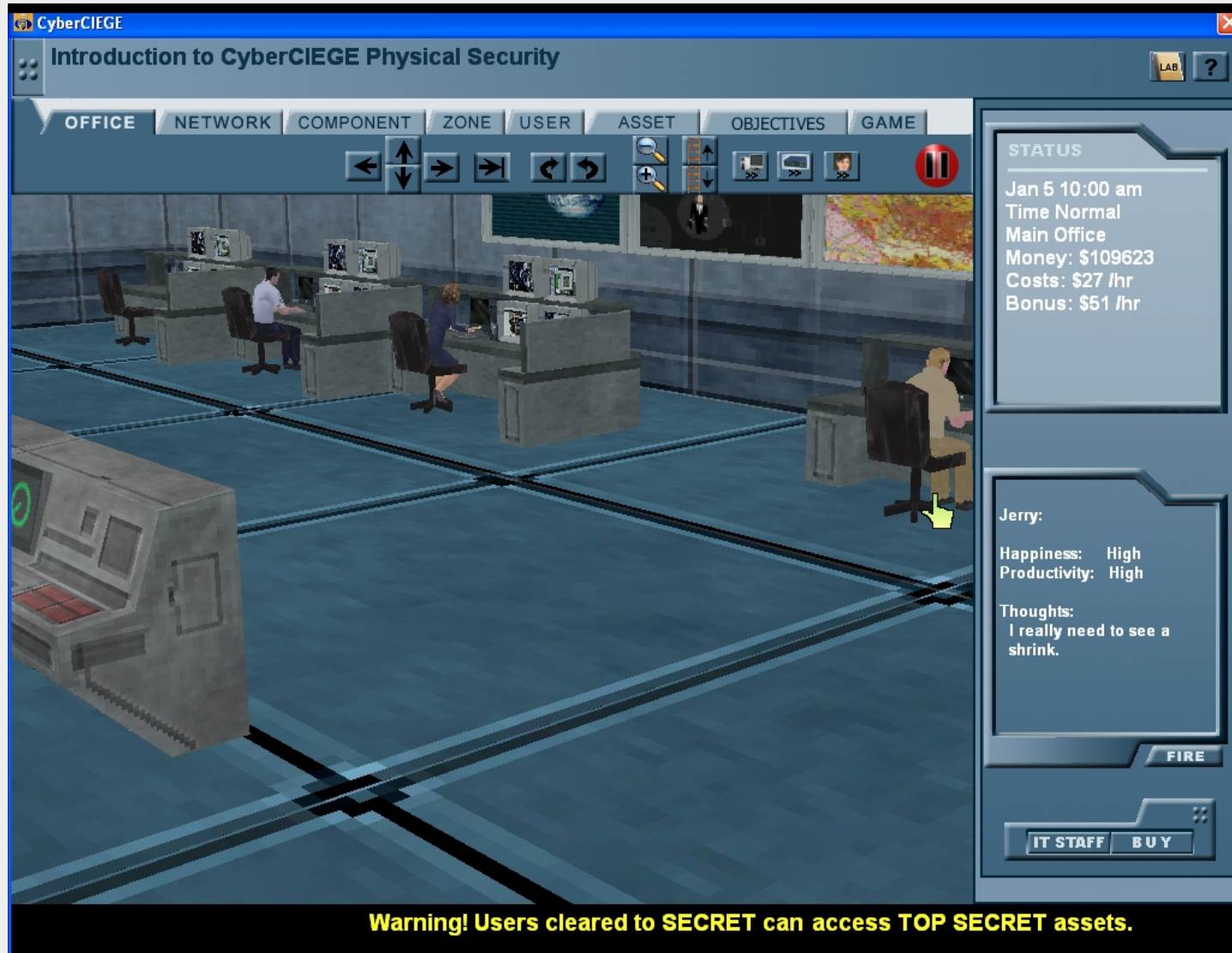
if path ahead ▾

do

else

CyberCIEGE

CS games



Some introduction is common

Tour Finder

The object of this game is to find the shortest possible **traveling salesman tour** through the green cities. The tour may start off at any of the cities, must touch upon each city at least once, and return to the originating city. It is fairly easy to find a good tour. Finding the best possible roundtrip is far less obvious.

Passive

CS games

The screenshot shows the Cisco myPlanNet game interface. At the top, it displays the Cisco logo, the game name 'myPlanNet', and the current era 'Dial-up Era' with the date 'Jul 1994'. There are buttons for 'DU', 'BB', and 'MC'. The 'Next Goals' section shows '513,542,050,000 Happiness' and 'Research Broadband Era'. A 'Researching' progress bar is visible in the top right.

On the left, a summary of resources is shown:

Available Cash:	9,188,000	PlanNet Oros:	
Monthly Income:	2,511,110	PlanNet Oros:	
Customers:	423,158		

On the right, a table shows various metrics:

Business Happiness:	244,568
Resident Happiness:	269,470
Businesses:	986
Residents:	82,443

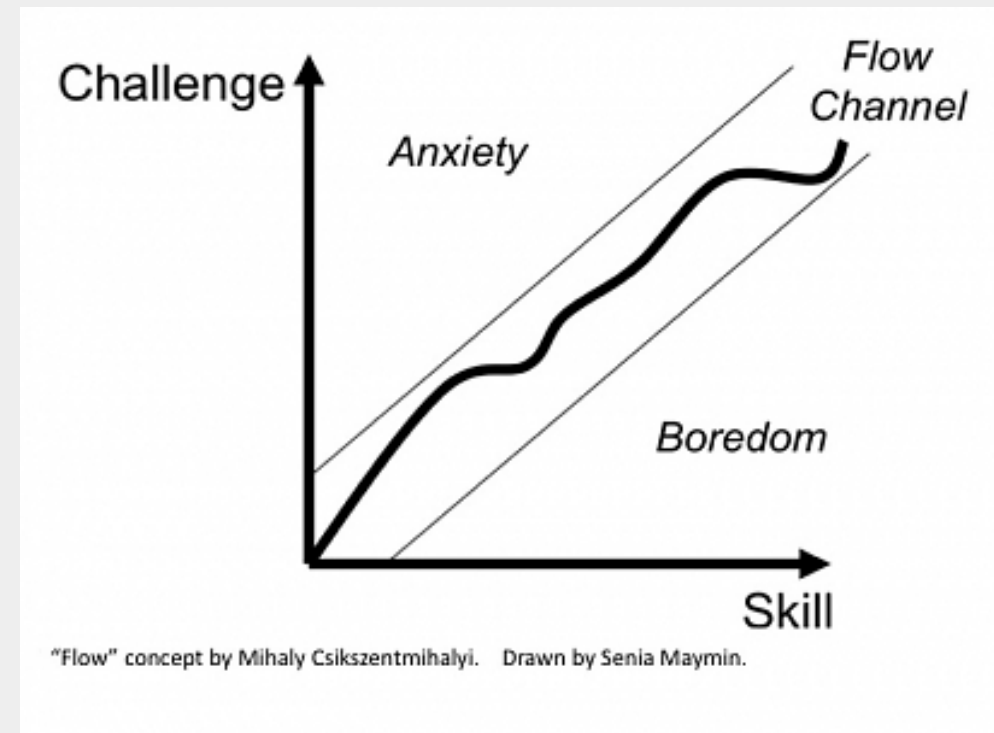
The main content area features a notification box titled 'You just learned World Wide Web WWW'. It includes a small image of people in a classroom setting. The text describes the development of the WWW and lists prerequisites: 'Email', 'Firewall', and 'Instant Messaging and Broadband Era'. The cost is '1,500,000 PlanNet Oros' and 'Services allowed' is 'None'. Buttons for 'Disable' and 'Close' are present.

At the bottom, a navigation bar contains buttons for 'Main Menu', 'Connect Citizens', 'Network Operations', 'Service Operations', 'Research', 'Game Information', 'Map', 'Status', and 'Tutorial'.

Flow

- Absorbed by activity
Challenging enough to be interesting
Not too challenging
- More time on task
- ZPD

CS games



Adjust difficulty

CS games

BINARY

128	64	32	16	8	4	2	1	
-----	----	----	----	---	---	---	---	--

Score 100
Level 1
Lines Left 14

0 0 0 0 0 0 1 0 =

128	64	32	16	8	4	2	1
-----	----	----	----	---	---	---	---

Pause game
Music On
Change Music
End Game

Manufactoria

CS games

Robotoast! Parts Placed: 0

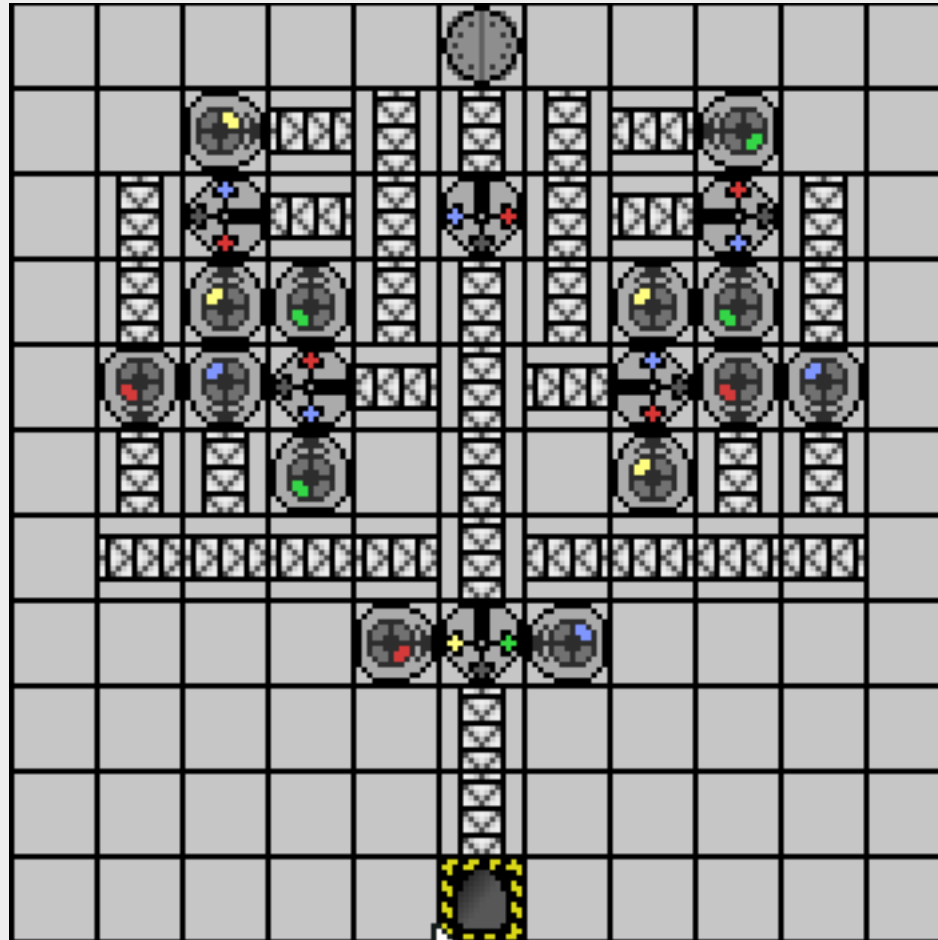
The game interface features a 5x5 grid. A robot is positioned in the top row, second column. A component, represented by a grey circle with a yellow border, is located in the bottom row, second column. A mouse cursor is positioned to the right of the grid.

ACCEPT:
Move robots
from the
entrance
(top) to the
exit
(bottom)!

Click or drag to delete components!

Manufoactoria

CS games



Limited flow

CS games

The screenshot shows the SimSE simulation interface. At the top, there's a menu with 'ARTIFACTS', 'CUSTOMERS', 'EMPLOYEES', 'PROJECTS', and 'TOOLS'. Below this is a 3D office environment with several desks, computers, and employees. A speech bubble from one employee says: "I am assigned to the Inception phase and ready to work -- let me know what to do. AND We have started a new iteration!". Another speech bubble says: "I am assigned to the inception phase and ready to work -- let me know what to do. AND We're off to meet with the customer to determine the scope and overall requirements of the project, as well as to create a project plan!". A third speech bubble says: "Tool(s) have been purchased!". A fourth speech bubble says: "We are now officially in the inception phase -- which of us do you want to work on this phase?". On the right side, there's a 'Current Activities:' list with the following entries:

- Amalia
- Anne
- Corey
- Dwight
- Assigned to Inception phase
- Elizabeth
- Erica
- Assigned to Inception phase Meeting with customer
- Gretchen

At the bottom, there's a detailed view of an employee named Gretchen:

Type: SoftwareEngineer
 Name: Gretchen
 ProjectManagementSkill: high
 ArchitectureSkill: low
 RequirementsSkill: high

DesignAndDevelopmentSkill: low
 TestSkill: high
 PayRate: 500.00
 Idle: false

On the right, there's a 'TIME ELAPSED' section with a 'TICKS' counter and buttons for 'NEXT EVENT', 'ADVANCE CLOCK', and 'STOP AT EVENTS'.

Anti-flow?

CS games

The screenshot shows the Cisco myPlanNet game interface. At the top, it displays the Cisco logo, the game name 'myPlanNet', and the current era 'Dial-up Era' with the date 'Jul 1994'. There are buttons for 'DU', 'BB', and 'MC'. A progress bar shows 'Next Goals' at 513,542,050,000 Happiness, with a sub-goal for 'Research Broadband Era'. A 'Researching' progress bar is also visible.

On the left, a summary of resources is shown:

Available Cash	9,188,000	PlanNet Oros	
Monthly Income	2,511,110	PlanNet Oros	
Customers	423,158		

On the right, a table shows various metrics:

Business Happiness	244,568
Resident Happiness	269,470
Businesses	986
Residents	82,443

The main content area features a notification window titled 'You just learned World Wide Web WWW'. It includes a small image of students in a classroom and a detailed text description of the technology. Below the text, it lists the cost (1,500,000 PlanNet Oros), prerequisites (Email), technology discoveries allowed (Firewall, Instant Messaging, and Broadband Era), and services allowed (None). Buttons for 'Disable' and 'Close' are present in the top right of the notification.

At the bottom of the interface, there is a navigation bar with buttons for 'Main Menu', 'Connect Citizens', 'Network Operations', 'Service Operations', 'Research', 'Game Information', 'Map', 'Status', and 'Tutorial'.

Longevity

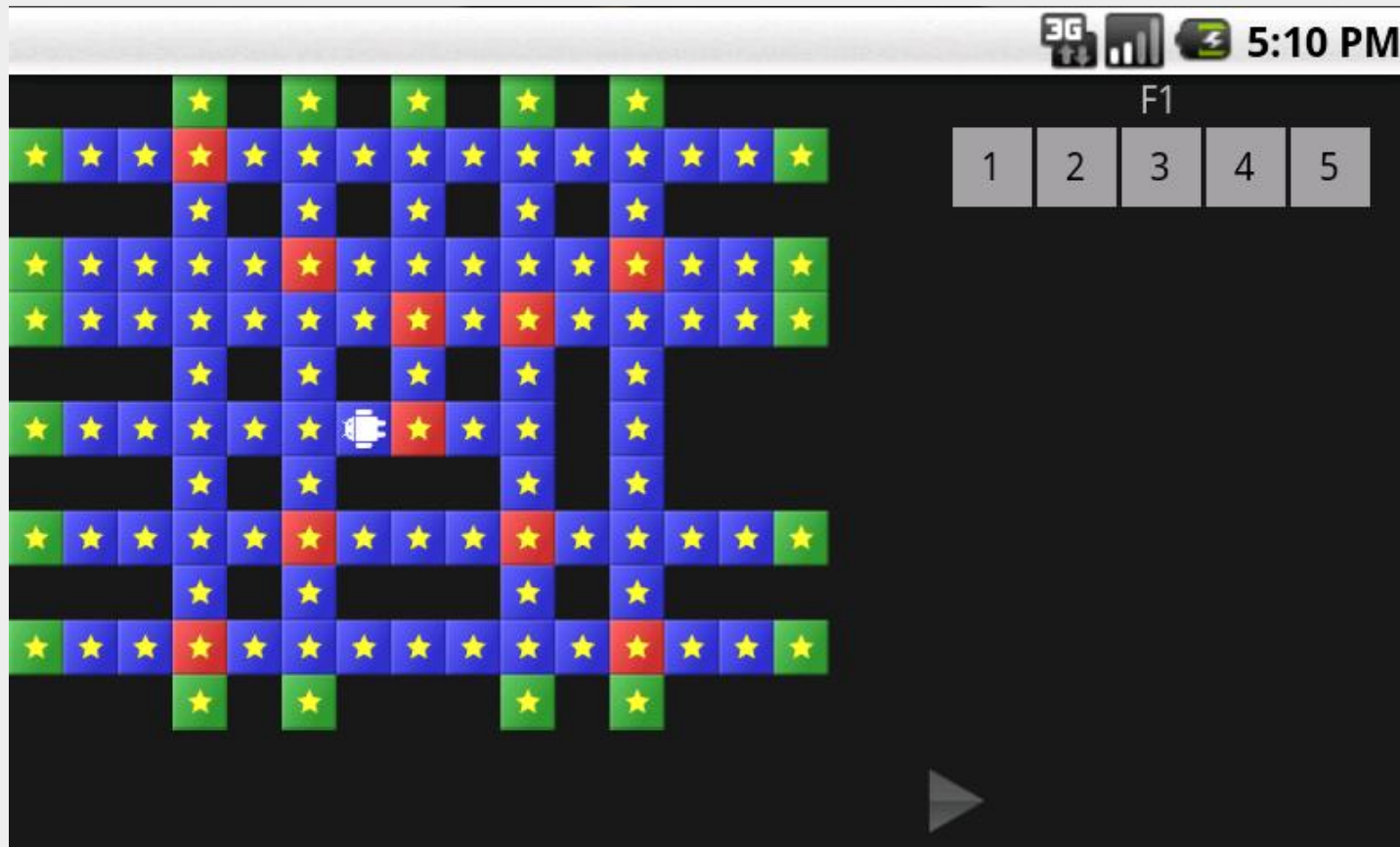
- Time on task improves learning - generally
- Classic games replayable by definition



RoboZZle

- User-defined layouts

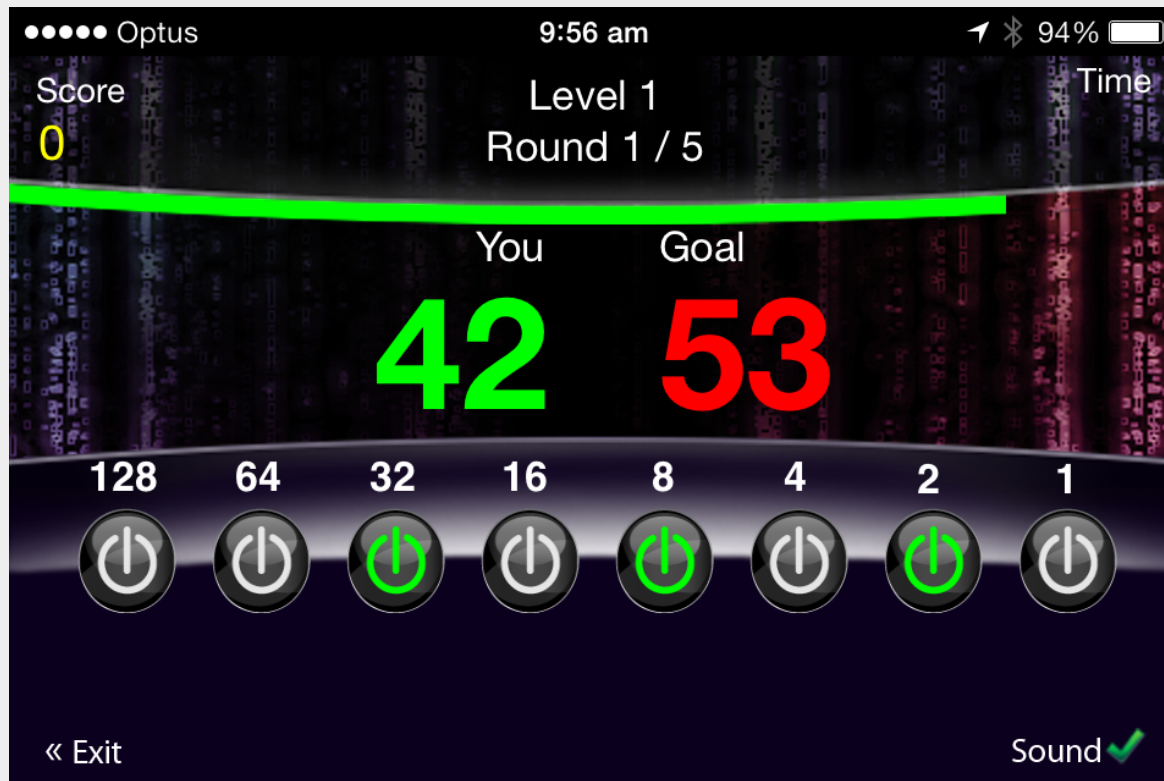
CS games



Binary games

- 8-bits only
- Speed can improve

CS games



Small games with longevity

- Only one puzzle available
- Generalisable

CS games

1	2	3	4
2			
3			
4			

Rows (Across):

1. "2 Down" x 2
2. A triangular number
3. The cube of ("4 Down" - 2)
4. "3 Across" + "3 Down"

Columns (Down):

1. NOT "2 Across"
2. NOT "1 Across"
3. "2 Across" x 2
4. "4 Across" - "1 Across"

Practical issues

- Freedom given to players
- Length of play
- Debriefing to maximise learning
- The list is growing and shrinking

CS games



Life size RoboRally

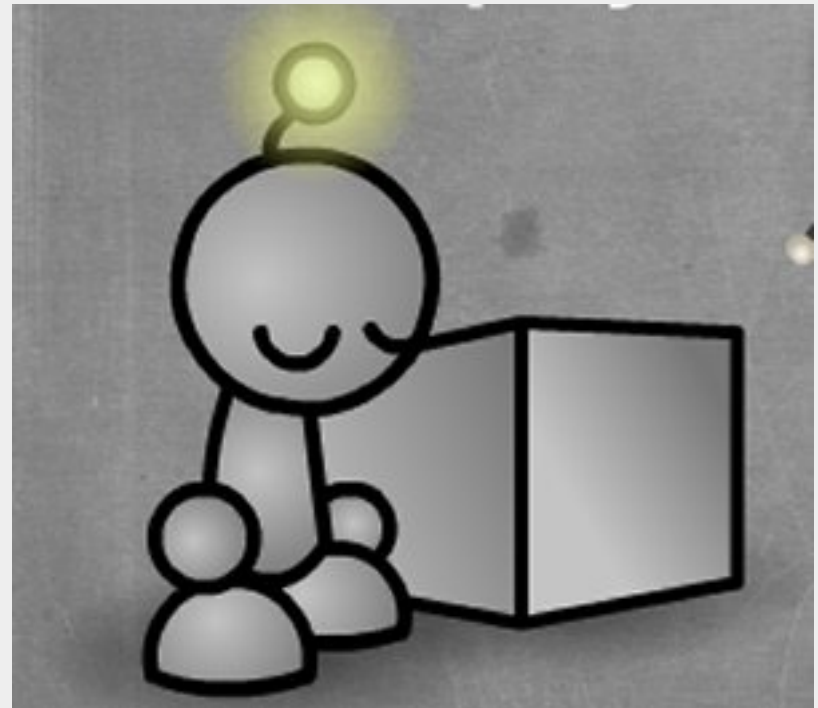
CS games



<http://www.andycollins.net/Personal/GwenCon/2005.htm>

Conclusion

- Many games suitable for school use
- Limited range of topics
- Many considerations for choosing games



<http://tinyurl.com/csedgames>

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