Evaluation of games for teaching Computer Science

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Why games?

- Engagement
- 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?

- **Rules:**
  New legislation which alone counts

- **Make-believe:**
  Second reality or free unreality

- **Non-productive Educational:**
  Teaches a CS topic: better understanding or skill

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Roger Caillois (1913-1978)
Continuum

- Obligatory play?
- Is binary make-believe?
- Replayability?
Finding 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)
Sitzmann and Callois

- Game

- Not a game
# Types of games found

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
<th>Hours required</th>
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<tr>
<td></td>
<td>Free</td>
<td>Low</td>
</tr>
<tr>
<td>Desktop</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Mobile</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Browser</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>Unplugged</td>
<td>9</td>
<td>0</td>
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</table>
Topics covered

- Graphs
- Cyber security
- Software engineering models
- History of networking
- Turing machines
- Binary
- Run-length encoding
- Sorting/searching algorithms
- Traveling salesman problem
- Networking and Routing
- Programming concepts
## 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
<table>
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<th>Programming concepts</th>
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<td>Conditionals</td>
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<tr>
<td>Loops</td>
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</table>
Light bot

Rotate the Bot with these.
Lightbot 2 (recursion)
Cargobot
RoboZZle (recursion)
Cisco Binary
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

UC University of Canterbury

CS games
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: ?

Submit Answer

(10 left to go)

<< MAIN MENU
Binary number quiz
Binary fun

written by jerry wolski

1 0 0 1 0 0 0 0

144

Round 1

149

NEW GAME

START ROUND

STOP GAME

GO

press space

149

DECIMAL

4

TIMER

ABOUT

CS games
Binary flash cards

What is the base 10 equivalent?
Cross-binary app
Binary game
Binary Maglock

MANUAL INPUT
LOCAL SUBSYSTEM ACCESS ENABLED
SUBSYS ID = 86
ACCESS CODE =

LCARS 10
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)
myPlanNet (history of networking)
Orange game
Mind Share (networking and binary)
CTRL-ALT-HACK

**CS games**

**ROXANA**

- **11 HARDWARE HACKING**
- **11 SOFTWARE HACKING**
- **16 CRYPTOANALYSIS**
- **10 NETWORK JUICE**
- **10 SOCIAL ENGINEERING**

Be careful when hacking into another's system, Roxana asks the player if they can substitute her cryptanalysis skill for the Hardware Hacking or Social Engineering. This substitution only applies to one task.

A big fan of elegant math and detective stories, Roxana is a hacker that enjoys turning any problem into a math puzzle.

**MISSION**

**One Hacker, Won Vote**

The audit target an electronic voting machine needed to be hacked in time for an election.

- **LOCKPICKING**
- **HID PROOFING**

Pick the lock to locate a safe that has the manufacturer's master key. Once you have access to the system it means—enter the software.

- **SOFTWARE HACKING**

Use your reverse engineering skills to discover ways to unobtrusively change votes.

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

**Failure:** -1 Hacker Cred

**Cost:** $4K

**BAG OF TRICKS**

**Dumuster Diving**

You don't mind getting dirty. You're happy to dig through company's garbage to look for an shredded specs, documentation, and inter-office memos. This time the client's guards are vigilant, and it's getting tougher, then go through all the trash off-site.

Play this card during a Mission. All your Hardware Hacking rolls for the Mission are automatic successes. Discard this card after use.
SimSE (Software Engineering)
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.

- Define a traveling salesman tour by clicking your left mouse button on circles.
- Type the letter 'r' 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 's' 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
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
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
Blockly level 1

Stack a couple of 'move forward' blocks together to help me reach the goal.
Blockly level 5
Blockly level 9

You have 6 blocks left.

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

Run Program
CyberCIEGE

Introduction to CyberCIEGE Physical Security

Warning! Users cleared to SECRET can access TOP SECRET assets.
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Passive
Flow

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

"Flow" concept by Mihaly Csikszentmihalyi. Drawn by Senia Maymin.
Adjust difficulty
Manufactoria

Robotoast! Parts Placed: 0

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

Click or drag to delete components!
Manufactoria
Limited flow
Anti-flow?

The development of the World Wide Web (commonly abbreviated as the Web or WWW) revolutionized the way information was presented on the Internet. Prior to web browsers, people used applications that were predominantly text-oriented such as Gopher. Web browsers allowed people to surf different websites containing text and images using clickable hypertext links (HTTP) to various Uniform Resource Locators (URLs). The Internet suddenly became easier to use. Businesses began to host websites to reach their customers and eventually, after security enhancements, billions of dollars in e-commerce now occurs over the web. As technology matured, Java scripting, flash programs, and video were added to boost the web experience.

This is a technology.
You have discovered this technology.
Cost: 1,500,000 PlanNet Oros
Prerequisites: Email
Technology Discoveries Allowed: Firewall
and Instant Messaging
and Broadband Era
Services allowed: None
Longevity

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

- User-defined layouts
Binary games

- 8-bits only
- Speed can improve
Small games with longevity

- Only one puzzle available
- Generalisable

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
Life size RoboRally

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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