

Exploring Visualisation and Game-Based Learning tools for teaching Data Structures and Algorithms

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Literature Review Seminar

Research Intent and Summary

What we found...

- ▶ Relatively few Game-Based Learning tools for DSA
- ▶ Game-Based Learning (GBL) tools and Algorithm Visualisations (AVs) are proven tools to improve learning outcomes
- ▶ Even fewer learning tools contain both GBL and AVs

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We propose further research into a tool that offers GBL within a game world, alongside AVs that take advantage of the analogies and interactivity afforded by said game world.

Why DSA?

Data Structures and Algorithms are an essential topic in Computer Science-related fields, and form the foundation of many higher-level concepts in CS.

DSA Curriculum

The ACM CS2013 provides guidelines on subjects that should be taught in an undergrad CS course. Algorithms & Complexity is identified as a core Knowledge Area and within that the knowledge unit of Fundamental Data Structures and Algorithms.

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Our Implementation

We will focus on teaching Fundamental DSA for the purposes of the tool we intend to develop.

Fundamental DSA in ACM CS2013

- ▶ Simple Numeric Algorithms
- ▶ Sequential and Binary Search
- ▶ Quadratic and $\Omega(n \log(n))$ sorting algorithms
- ▶ Hash tables and collisions
- ▶ Binary search trees
- ▶ Graphs and common graph algorithms
- ▶ Heaps
- ▶ Pattern matching/string algorithms

DSA Learning Outcomes in CS2013

We will target some of the learning outcomes outlined in CS2013...

1. Implement basic numerical algorithms.
2. Be able to implement common quadratic and $O(N \log N)$ sorting algorithms.
3. Discuss the runtime and memory efficiency of principal algorithms for sorting, searching, and hashing.
4. Demonstrate the ability to evaluate algorithms, to select from a range of possible options, to provide justification for that selection, and to implement the algorithm in a particular context.

What is Algorithm Visualisation?

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What is Game-based Learning?

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- ▶ Educational games are argued to appeal to students of all ages
- ▶ Students can learn at their own pace and re-attempt problems
- ▶ Understanding is enhanced through the use of immersive environments
- ▶ Some games designed solely for entertainment have been shown to be highly educational

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There also exists a special relationship between digital educational games and computer science education, as programming is the foundation of said games.

7 Billion Humans

A wildly popular puzzle game (rated “Very Positive” on Steam) from developers of “World of Goo” where plays program workers (humans) to perform tasks to solve the puzzle. Uses a block-based assembly-like language for programming. Of interest is that this wasn’t designed as a educational game. Unfortunately no studies on the educational nature of this game.

Local Maximums

Pick up and shred the largest data cube in each group.

01 mem 1 = nearest shredder

02 mem 3 = set 0

03 step

04 step

05 forEachDir as mem 2

06 if mem 2 > mem 3 ...

07 mem 3 = set mem 2

08 pickUp mem 3

09 giveTo mem 1

Script List:

- step
- pickUp
- drop
- giveTo
- write
- nearest
- calc
- set
- if
- jump
- forEachDir
- end
- ~~~~~

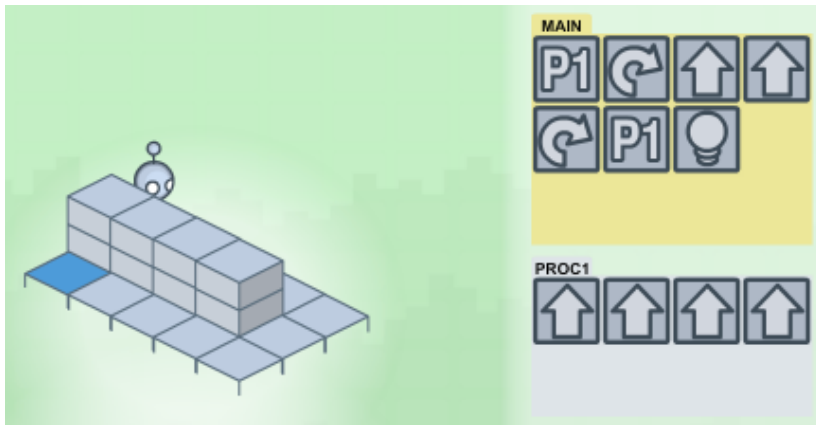
Grid Data:

| | | | | | |
|----|----|----|----|----|----|
| 51 | 52 | 86 | 1 | 53 | 40 |
| 62 | 41 | 90 | 52 | | |
| 20 | 94 | 48 | 14 | 69 | 50 |
| 28 | 98 | 41 | | | |
| 45 | 70 | | | | |
| 56 | 73 | 23 | | | |
| 25 | 23 | 96 | 21 | 53 | 47 |
| 81 | 38 | 8 | 92 | 94 | 18 |
| 42 | 27 | 41 | 37 | 78 | 76 |
| | | | 35 | 94 | 59 |

Controls: 0.5x 1x 12x

Lightbot

A more traditional educational game, where you navigate a robot (lightbot) around the map. Programming uses a much simpler block & icon based language. Unlike 7BH, lightbot was designed with teaching basic programming in mind.



Design and Large-scale Evaluation of Educational Games for Teaching Sorting Algorithms

This paper focuses on evaluating DSA games with students, in order to determine the effectiveness of (their) GBL.