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

Edward Zhang Simon Su

Department of ECSE
The University of Auckland

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

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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
- Quadractic 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 $\Omega(n \log(n))$ 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?

A note on Simon

Simon's section goes here, but unfortunately he's decided to produce it in Keynote.

What is Game-based Learning?

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- 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.

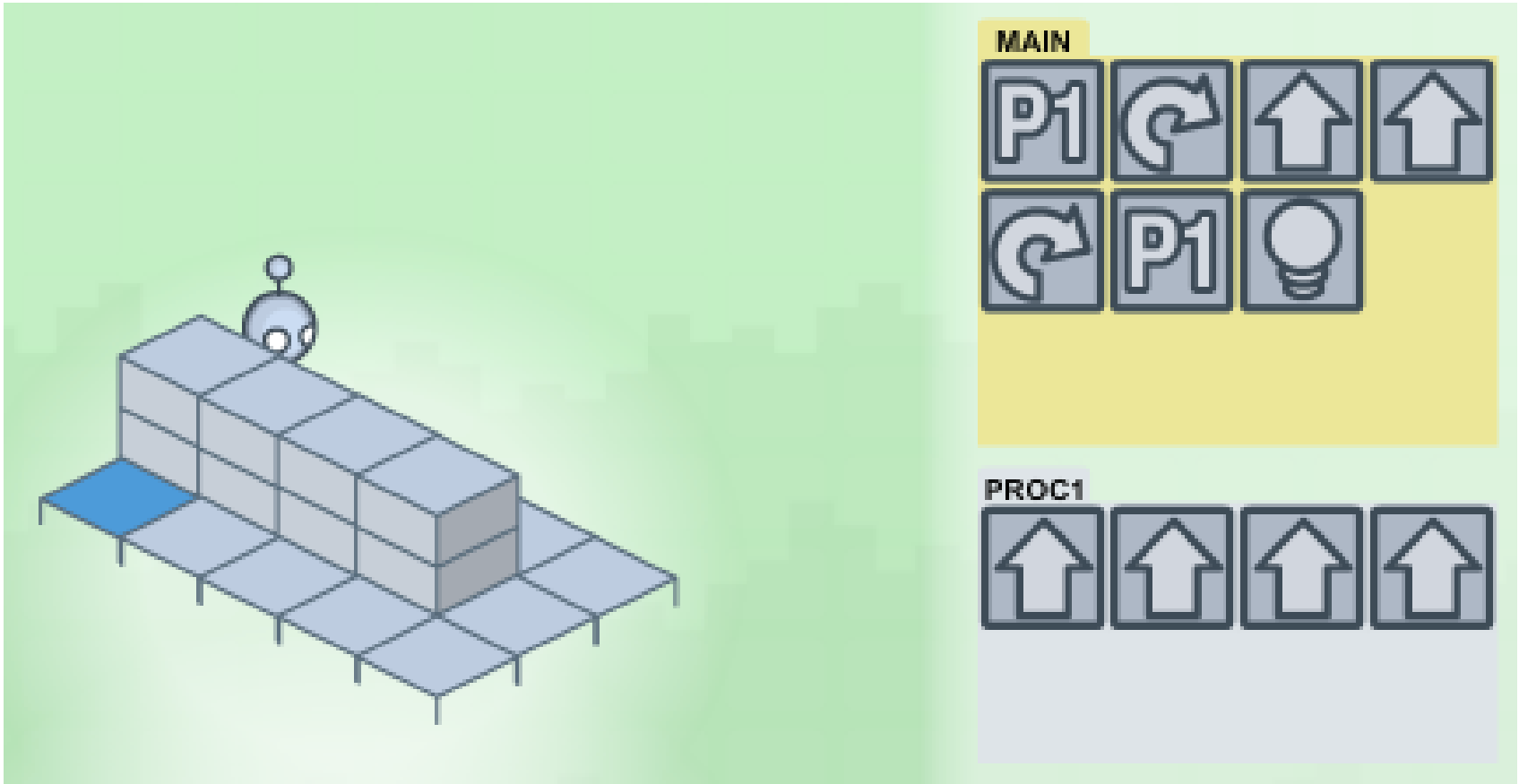
7 Billion Humans

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.


Our entire lives have led to this exact moment.
0.5x
1x
12x
step
pickUp
drop
giveTo
write
nearest
calc
set
if
jump
forEachDir
end
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

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.


MAIN
P1
P1
PROC1

A evaluation of GBL with boardgames

The paper "Design and Large-scale Evaluation of Educational Games for Teaching Sorting Algorithms" focuses on evaluating DSA games with students, in order to determine the effectiveness of (their) GBL.

A evaluation of GBL with boardgames

The paper "Design and Large-scale Evaluation of Educational Games for Teaching Sorting Algorithms" focuses on evaluating DSA games with students, in order to determine the effectiveness of (their) GBL.
Games tested involved board and digital games for teaching Heapsort and Quicksort.

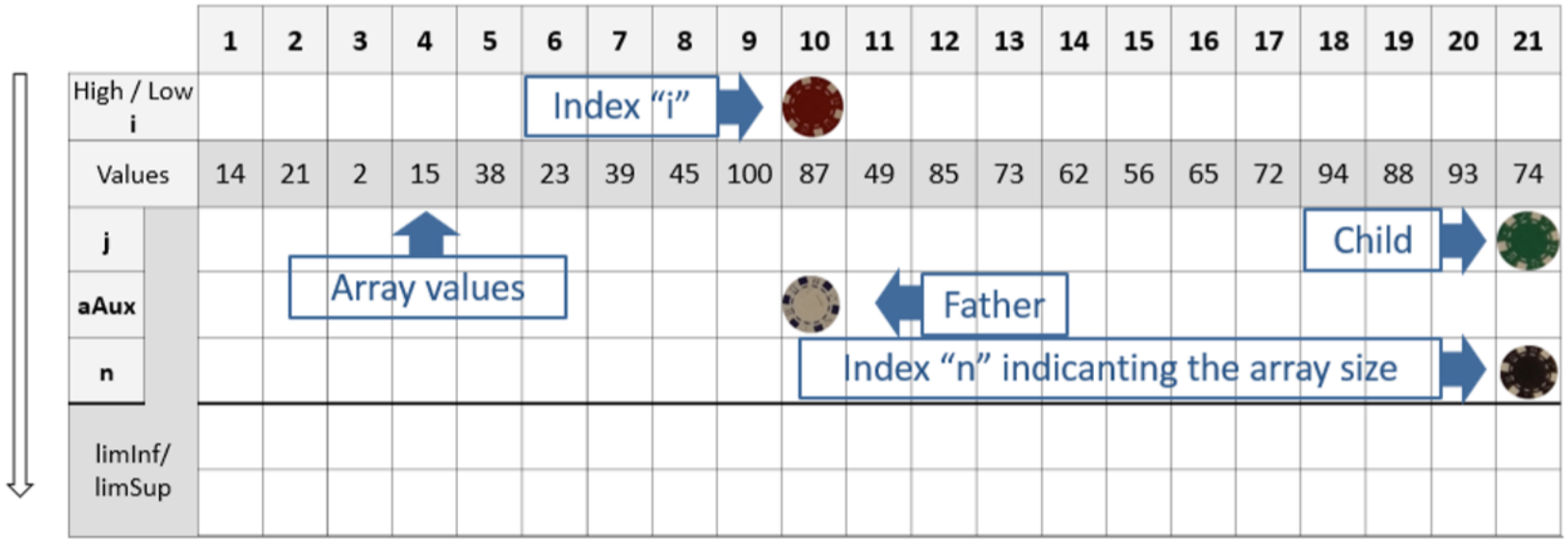


Fig. 5. Board Game for teaching the Heapsort Algorithm.

Evaluation

Authors evaluated the games across ≥ 300 students, across different year levels and courses. Students played the game and evaluated using a questionnaire based on MEEGA (Model for the Evaluation of Educational GAmes).

MEEGA

- Based on research in evaluation models and analysis
- Measures various dimensions of player experience and usability
- Measurement instrument (questionnaire) designed based on the dimensions
- Analysis of these questions in order to quantify game quality

Analysis Questions

The authors used the evaluation to answer these analysis questions...

1. Do the games motivate Students?
2. Do the games provide a positive user experience?
3. Do the games contribute to learning?
4. What are the differences in the quality of the (three games tested) in relation to the above?

Evaluation evaluation

- No pre-test measurement
- Self-assessment only
- Common evaluation model (MEEGA)

PlayIt: Game Based Learning Approach for Teaching Programming Concepts

Study at Massey University into the effectiveness of GBL for programming, using the game LightBot.

Evaluation Design

- Participants divided into three cohorts
- One played LightBot before attending classes
- One played LightBot after attending classes
- One did not use LightBot

Students filled out feedback immediately after survey and also at the end of study. Open ended questions and likert scale data. Student's pass rate was also analysed.

Evaluation evaluation

- No common evaluation model
- No pre-test measurement
- Academic performance analysed, but sample size too small