

Serious Games for Building Skills in Introductory Algebra and Computer Science Courses

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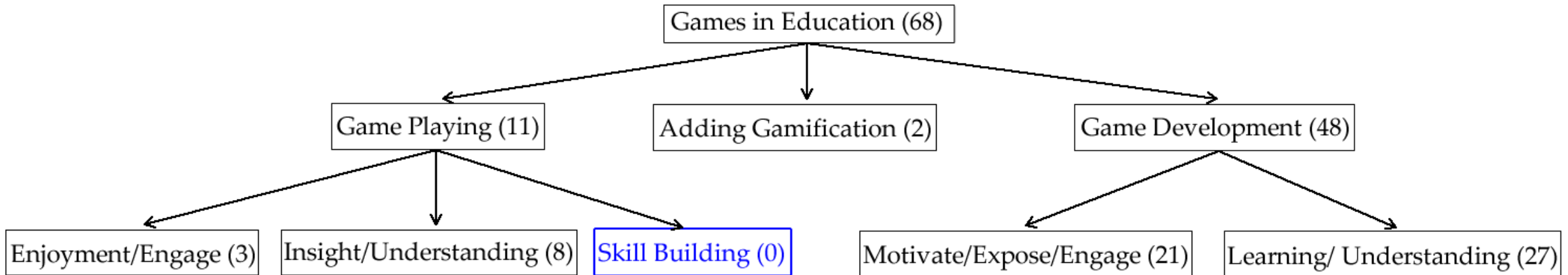
What are serious games?

- Serious games are games with a purpose beyond entertainment



“ Serious games are
MORE THAN
FUN.”

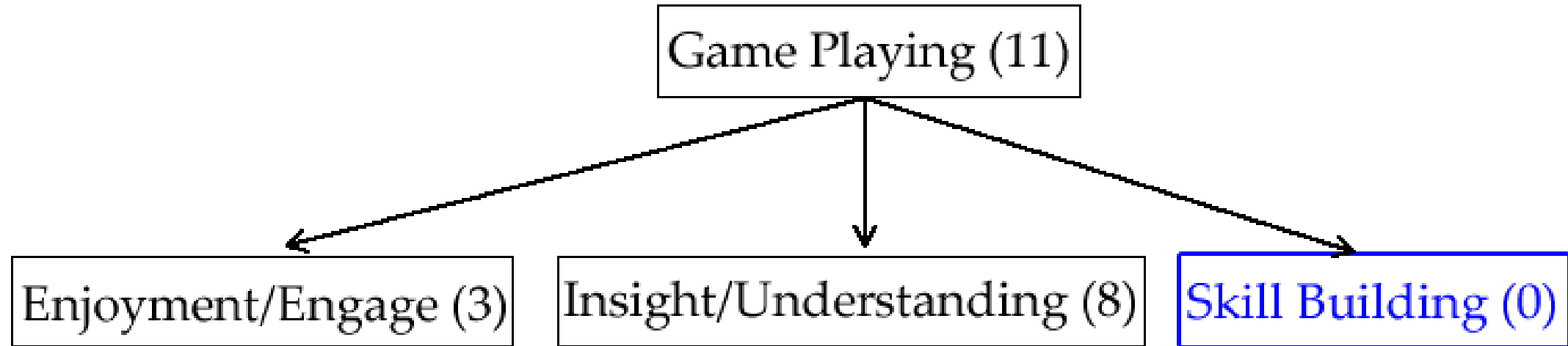
Serious games: taxonomy



Surveyed SIGCSE papers from 1995 - 2016

- Making games a "snap" with Stencyl: a summer computing workshop for K-12 (SIGCSE 2014, Jiangjiang Liu et al.)
- Life's a Game and the Game of Life: How Making a Game Out of it Can Change Student Behavior (SIGCSE 2013, Adrienne Decker and Elizabeth Lane Lawley)

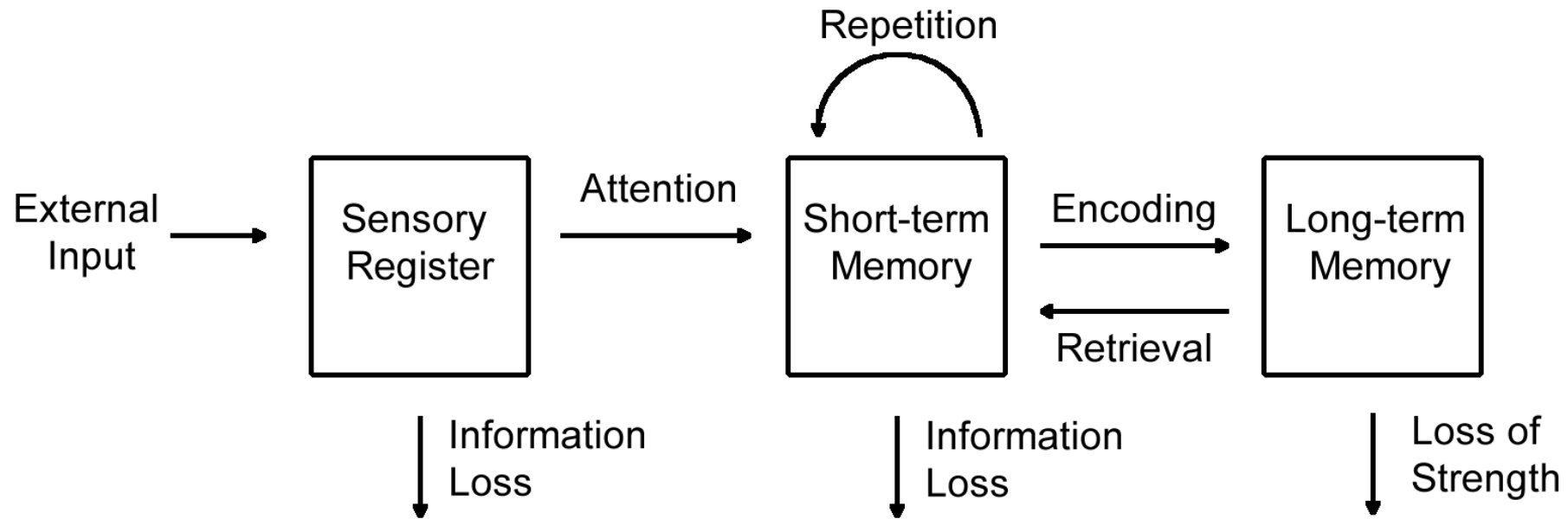
Game playing



- Using Game Days to Teach a Multiagent System Class (SIGCSE 2004, Leen-Kiat Soh)
- Design Insights into the Creation and Evaluation of a Computer Science Educational Game. (SIGCSE 2016, Britton Horn et al.)

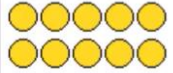




Memory model - short-term to long-term memory

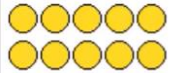

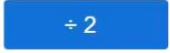

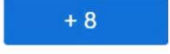
- Atkinson and Shiffrin's Memory model
- Jonathan Sweller's Cognitive Load Theory



Solve for x game


Score: 0 Time: 2 Level: 1/10


Time:     

Balance:     


Solve for x using the operations on both sides of the equation

$2x = 8$





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Exponent multiply game

Score: 0 Time: 0 Level: 1

a^1 a^1

a^1

Feedback

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Interval notation game

The screenshot shows a game interface for interval notation. At the top, a dark header bar contains the following information: a trophy icon followed by "Score: 999", a clock icon followed by "Time: 16", a bar chart icon followed by "Level: 2/10", and icons for pause, refresh, volume, and notifications. On the left side, there is a "Play" button. The main area is a light blue background. In the center, there is a horizontal number line with arrows at both ends, ranging from -5 to 5 with tick marks at every integer. Below the number line, there is a small black stick figure character. At the bottom of the screen, there is a row of input buttons: an opening parenthesis "(", the digit "0", an upward arrow "↑", a downward arrow "↓", a comma ",", the digit "0", an upward arrow "↑", a downward arrow "↓", and a closing parenthesis ")", followed by a "GO" button. In the bottom right corner, there is a "Feedback" button with a speech bubble icon.

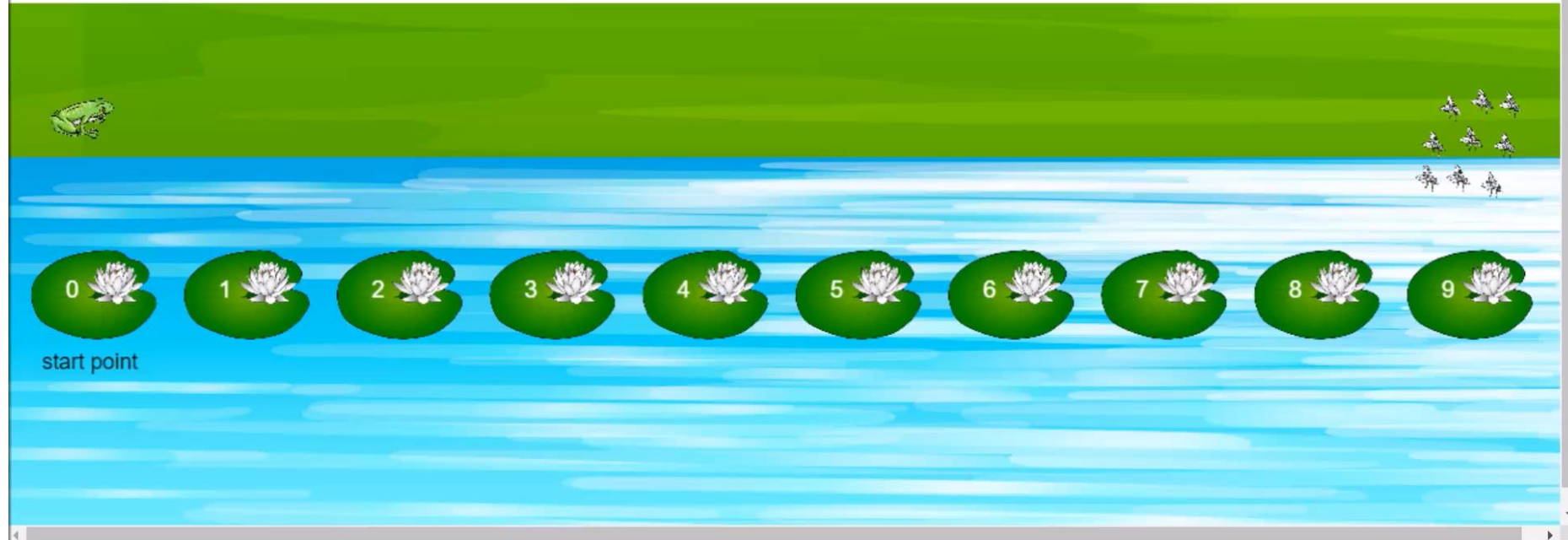
For-loop game

Score: 9 Time: 10 Level: 2

Complete the for loop, then click Run

```
for( int i = 0 ; i < 0 ; ++i )  
    JumpTo( i );
```

Run



If/else conditional game

The screenshot shows a game interface with a dark grey header and a white main area. The header contains the following information: "Slower" and "Faster" buttons on the left; "Score: 0" and "Level Target Score: 4" in the center; "Time: 0" on the right; and "Level: 1/6" on the far right. There are also icons for pause, refresh, volume, notifications, and help. The main area is divided into two sections by a vertical line. On the left, a car icon is on a road, and the text "x = 3" is displayed above it. On the right, there is a vertical stack of four horizontal bars representing conditional logic. Each bar has a label on the left and a colored square on the right. The bars are: 1. "if" with "x == 0" and a red square. 2. "else if" with "x == 1" and a grey square. 3. "else if" with "x == 2" and a black square. 4. "else" with an empty space and a dark red square. A mouse cursor is pointing at the "else if" bar with "x == 1".

Future games

- Set notation (CS-oriented)
- Nested for-loops
- Interval counting

The screenshot shows a game interface with a dark header bar. On the left is a 'Play' button. In the center is a cartoon alien in a UFO. On the right, the score is 0, time is 16, and level is 1/10. Below the header, the inequality $X > -6 \&\& X < -2$ is displayed. At the bottom, a number line from -5 to 5 is shown with a blue shaded region between -6 and -2, and a blue circle at -2. There are 'Clear' and 'GO' buttons. A 'Feedback' button is in the bottom right. Copyright text is at the bottom left.

Score: 0 Time: 16 Level: 1/10

Play

$X > -6 \&\& X < -2$

Clear GO

Feedback

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Discussion

- Preliminary Survey Data:
 - Ways to improve the games
 - “The game made me more focused on completing the game rather than understanding the concept”
- Challenges
 - How to collect improvement data
 - Difficult to conduct a controlled study

Our Website

The screenshot shows a website with a dark navigation bar at the top containing links for Home, Games, About Us, Research, Acknowledgements, and Contact Us. The main heading is 'Serious Games'. Below it is a section titled 'About Serious Games' with a paragraph explaining the term and its applications in health, economics, defense, and education. A second paragraph states the website's focus on building skills through repetition in college-level mathematics and computer science. Below this is a 'Math Games' section featuring three game thumbnails: 'Solve for x' (a balance scale with the equation $3x - 3 = 27$ and five yellow circles), 'Exponent multiply' (a green bar with boxes for a^{-3} , a^1 , and $2a^5$, and labels a^{-1} and a^3 below), and 'Interval notation' (a number line from -5 to 5 with a rocket ship and clouds below).

- <http://www.cs.ucr.edu/~vahid/seriousGames/>