Sample Pac-Man Lesson Plan
Day 4 – 50 minutes
Scalable Game Design Summer Institute 2010

Note: Red links take you to portions of the tutorial. Blue links provide background information to aid in teaching.

1. Learning Objectives:
   In this unit, students will create a simple but complete version of Pac-Man game while expanding knowledge of the AgentSheets software program. Students will apply basic and advanced design process to identify objects “agents” and interactions “operations”. Throughout this unit, students will be introduced to computational thinking patterns and skills, including basic object interaction, creating object instances, rule based programming, and message sending. Over the course of the unit, the difficulty of the game with ghosts with random movement will be contrasted to the difficulty of the game with ghosts with artificial intelligence.

   In this lesson, Pac-Man starts emitting an odor – we hope a pleasant one! – as we start programming the artificial intelligence of the ghosts. We are working our way to creating a game with artificial intelligence.

2. Standards:
   ISTE (International Society for Technology in Education) NETS (National Educational Technology Standards)
   • #1a apply existing knowledge to generate new products
   • #4b plan and manage activities to develop a solution or complete a project.
   • #4d use multiple processes and diverse perspectives to explore alternative solutions.
   • #6c troubleshoot systems and applications.

   ISTE NETS are referred to by CDE Performance Standards for Teachers #7- Technology, which states, “The teacher will have demonstrated the ability to instruct students in basic technology skills. He/She will: … instruct students in basic technology skills by imbedding them in their standards-based, content instruction (7.5.3)”

   Please check with your district’s technology department to see if there are additional standards at the district or school level.

3. Anticipatory Set / Modeling: 5 minutes
   Set the stage by spraying strong cologne or opening an air freshener in one corner of the room while students watch and time how long it takes for the smell to reach those close by and those in the opposite corner. Talk about the strength of the smell close by and farther away. This introduces the concept of diffusion.

4. Teaching: 25 minutes
   This would be a great time to pair up with your math or science content teacher -- team teach, invite as a guest teacher, or have content teacher teach in his/her own classroom if you share same kids, etc.
Discuss relevant computational thinking patterns in Pac-Man: Today we will be introducing Collaborative Diffusion.

- **Collision**: Pac-Man collides with ghosts.
- Artificial Intelligence using **Collaborative Diffusion**
- the **Hill Climbing** algorithm

Show the 2 video clips under “Basic Diffusion” from the link for **Collaborative Diffusion**.
(Note: Save the other two video clips on this page under “Simple Collaboration” for Day 6 of the lesson when we introduce the Hill Climbing Algorithm.)

Explain that the yellow pole represents Pac-Man (the highest value of scent) and that the slope of the hill tapers off the further away one gets from Pac-Man.

Explain the math behind the diffusion algorithm.

\[
 u_{0,t+1} = u_{0,t} + D \sum_{i=1}^{n} (u_{i,t} - u_{0,t}) 
\]

Where:
- \( n \) = number of neighboring cells used as input for the diffusion equation
- \( u_{0,t} \) = diffusion value of center agent
- \( u_{i,t} \) = diffusion value of neighbor agent (\( i > 0 \))
- \( D \) = diffusion coefficient (between 0 and 0.5)

A simplified version of this equation would be roughly equivalent to the average of the four neighboring sections on the grid. Using mathematical notation we might write this equation as:

\[
 S = \frac{u_1 + u_2 + u_3 + u_4}{4}
\]

Where \( S \) = scent at a particular cell on grid
- \( u_1 \) = scent of cell directly to the left
- \( u_2 \) = scent of cell directly above
- \( u_3 \) = scent of cell directly to the right
- \( u_4 \) = scent of cell directly below

To demonstrate this, follow the path to the right in the following spreadsheet. Explain to students that this will be happening in all directions away from Pac-Man with calculations occurring at a very high speed. We will see this tomorrow when we program collaborative diffusion into our games.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1000</td>
<td>250</td>
<td>62.5</td>
<td>15.625</td>
<td>3.90625</td>
</tr>
<tr>
<td>3</td>
<td>((A2+B1+C2+B3)/4)</td>
<td>((B2+C1+D2+C3)/4)</td>
<td>((C2+D1+E2+D3)/4)</td>
<td>((D2+E1+F2+E3)/4)</td>
<td></td>
</tr>
</tbody>
</table>
5. **Optional Activity: 15 minutes**

Before class, lay out a giant grid on the floor using masking tape.

During class, fill in the grid by having one student stand in each box. Designate one student near the center to be Pac-Man. (Optional: Hand this student the air freshener). Pac-Man’s $S$ value will be set to 1000. The people around him/her calculate their $S$ value on a piece of paper. Have students hold up their paper for others to see. Then others can calculate based on those values. This continues until all students have calculated a scent value. You may want to have calculators available to make calculations faster and/or more accurate.

Move the student designated as Pac-Man to another location near the periphery of the grid and ask students to repeat the calculations based on new proximity of Pac-Man.

Compare the two times through. How did the $S$ values change for those furthest away from Pac-Man?

6. **Closure: 5 minutes**

Restate the scope of the project. Tomorrow we will be programming the diffusion equation into our games. Begin students thinking about how this will need to be done. Some questions to ask might include:

- What agents need to transmit the smell? the background? the pellets? the walls?
- What other behaviors and agents do the students anticipate needing to program and create?
- Just because Pac-Man emits an odor, does this mean that the ghosts will pick it up? (We will be programming the hill climbing algorithm on Day 6 – which is what is needed to track the scent).

7. **Extension/Remediation** – Change the initial value of Pac-Man and ask students to calculate $S$ values individually. A sheet of $\frac{3}{4}$ to 1 inch graph paper works well. This can also be assigned as homework.