Image Representation Game Design Prototype

This is one of three game design documents created for the NSF-AISL Pathways funded project, AISL Pathways: The Role of Story in Games to Teach Computer Science Concepts to Middle School Girls (http://nuweb1.neu.edu/gramshouse/storyteach-project-description/). Each game is intended to introduce participants to one computer science concept, drawn from the Computer Science Principles framework developed by the College Board (see http://apcsprinciples.org/). Each game has three versions: (a) the basic game, which consists of puzzles or problem-solving activities within a game format, (b) game with context, which consists of the same kind of problem-solving activities situated in a fictional setting, that gives meaning to the activities , and (c) game with story, which embeds these activities in a more fully developed narrative, with a plot and resolution.

Learning Objective

Data can be represented in many different ways, and still have the same meaning. The different representations are for different purposes (faster, shorter, more visual, more hidden, more secretive). Changing from one representation to another has to follow agreed translation rules.

Game Overview

Players compete one-on-one(or two-on-two) to be the first to accurately translate one data image representation to (or from) its numerical representation, while guessing the meaning of the image. This game has a pre-game matching activity and 3 levels of play.

Players: Two players competing one-on-one (level 1) or two pairs of players competing two-on-two (levels 2 and 3)

Quick Match Game Warm-Up

Players: Four per table.
Introduction: (discussion of different representations for the same thing)
House – English
Casa - Spanish
43617461 – Ascii for the computer

Matchup:
This quick matching challenge introduces the general idea that images can be represented as numbers and vice versa. The idea is to stimulate brains into puzzle-solving mode, with the encode-decode games to deepen and extend learning. The facilitator will demonstrate how answer B matches image 1. If more help is needed use Answer D as a second demo.

Copy, and spread out on a table for all to see this set of simple gridded images:
https://drive.google.com/file/d/0Bx3zflThhEC0amxoaEx0UDdjYzg/view?usp=sharing
Also copy the answer key, and cut the number sets into 6 small pieces of paper.
https://drive.google.com/file/d/0Bx3zflThhEC0QnBQNVVtY2dIY1E/view?usp=sharing

Give one number set to each student, and challenge them to find its matching image.
Give all the players 5-8 minutes and see how many matches each table can make. Encourage players to talk and share their ideas about what the numbers mean.

Level 1 - Materials and Game Set-Up

For this two-player game, give each player in a competing duo (across the table from each other) a marker or pen and the following two pieces of paper.

1. **An encoded image** that discloses the number (e.g., 16) of black cells that the image contains. The images are different for <u>each</u> player. <u>Instruct both players to keep this image hidden from their opponent throughout the game</u>.

Number of Black cells: __16____

	A	B	C	D	E	F
1	0	0	1	1	0	0
2	0	1	1	1	1	0
3	1	0	0	0	0	1
4	0	1	1	1	1	0
5	0	0	1	1	0	0
6	0	0	1	1	0	0

2. **A blank grid** on which the encoded image will be revealed during game play. Instruct players to write the number of black cells at the top of the blank grid, and place this page where both players can see it, to cover the encoded image. The encoded image is seen by the player peeking under the blank grid on top.

Number of Black cells: _____

	A	B	C	D	E	F
1						
2						
3						
4						
5						
6						

Level 1 - Rules for Playing

1. The **goal** of the game is to reveal all of an opponent's black pixels by guessing their locations on a grid (similar to Battleships, for those who are familiar).
2. Two players alternate turns, with the younger player going first. **To take a turn**, a player calls out a row number and a column letter that corresponds to a cell on the opponent's grid (like Bingo, for those who are familiar).
3. Her opponent then peeks under the blank grid to see the selected square cell on the hidden grid and reacts in one of two ways:

- If the selected cell on the opponents' top revealed **grid** is ***blank***, the opponent must reveal the color of the cell on top, by looking at the value of the hidden cell below:
    - If the corresponding cell on her **hidden binary grid** is 0, the opponent places a dot in the cell on the top grid to indicate that this cell is white.
    - If the corresponding cell on the **hidden binary grid** is 1, the opponent colors in the cell on the top grid with her marker to indicate that this cell is black. The player whose turn it is gets to call out a second bonus coordinate, which can be either the same cell or a new one. (Only one bonus call per turn is allowed.)

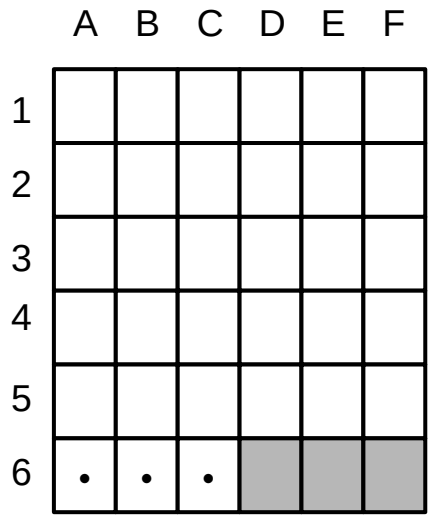
- If the color of the cell on the opponents' revealed top image has been ***already revealed*** (on a previous turn), the opponent must look below to see if there is a run of the same-numbered cells directly to its right. If so the top grid is revealed by the number of same color cells until the color changes, or the row ends. If the first cell to the right of the selected cell is a different number than the selected cell, then nothing new is revealed. See example below.

4. The **winner** is the player who reveals all of her opponents' black pixel cells first.

Strategy – Finding runs of black cells or runs of white cells are important to locate for the success of the player, to shorten the number of turns to win the game.

Example of a Turn

Player A is trying to reveal Player B's image. Player B's top revealed grid and hidden binary encoded image currently look like these:

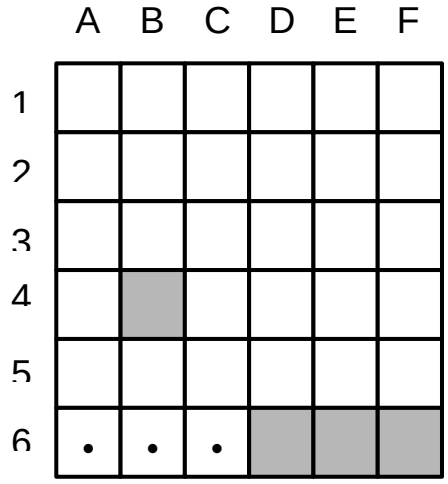


Player B revealed image

	A	B	C	D	E	F
1	0	0	1	1	1	1
2	0	1	1	1	1	1
3	1	0	0	1	1	0
4	0	1	1	1	1	0
5	0	0	1	1	1	1
6	0	0	0	1	1	1

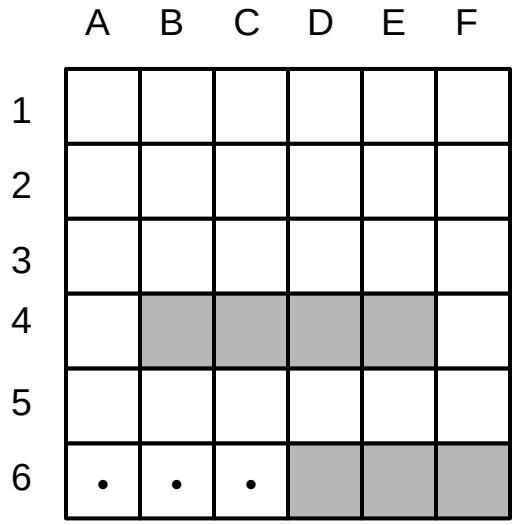
Player B hidden grid

Player A calls "4, B" which means she wants to reveal the cell at row 4, column B. Player B looks at her hidden encoded grid and sees that the cell at "4, B" contains a 1, and so she colors that cell black on the revealed image grid:



Player B revealed image

Because a black cell was revealed, Player A gets to call out a second bonus coordinate. Instead of calling out a new cell, she decides to call "4, B" again to see if she can reveal a run of blacks to the right of the revealed cell. Player B sees that there are three more cells that contain 1 before the number changes, and so Player B colors in all three cells:



Player B revealed

Player A's turn is now finished.

Players take turns until there is a winner.

The **winner** is the player who reveals all of her opponents' black pixel cells first.

Intermission Discussion Between Level 1 and Level 2

The facilitator defines Run length encoding, then demonstrates with this example:

1B2W3B2W = Run Length encoding
10011100 = Binary encoding
Whose image is :

Explain that there are many different **protocols** . Protocols are rules for encoding data which changes the look of the data but not the meaning of the data, and Level2 uses a different protocol than players used in Level 1.

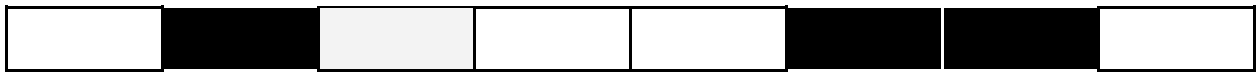
In the Run length encoding above, the data is B for black and W for white, but could just as easily be R for red and B for blue. The Protocol also includes Runs of variable length. For example, the black has a run of length three and the white has two runs of length two.

Level 2 – Game Overview

In this two-against-two level, player-pairs are shown the same numerical encoding, with the goal of drawing the image represented by the encoding, one row at a time, accurately. The encoding uses a new protocol, one which players have not seen yet.

Example of an Encoded Row (for Discussion**)**

Give player-pairs: 0130210
which is equivalent to: 01000110
whose image is:



For each row, player-pairs will have a few seconds to discuss what the new protocol means and decode the image, playing against the other player-pair. (They will not receive the equivalent in 1's and 0's in the second row—just the new protocol.)

Accuracy of decoding the message within the time constraint is the main goal of the game.

Example of an Encoded Image (for Discussion)

Each player-pair is given the same encoding such as the example below. The objective is to decode the encoded message to form an image.

Example Run Encoding provided one row at a time:
80
02120210
104101
01021010
20120120
302130
302130
1601

Example resulting Image:

	A	B	C	D	E	F	G	H
1								
2								
3								
4								
5								
6								
7								
8								

Level 2 - Decoding Messages with Run Encoding

Set-Up and Rules for Playing

Facilitator Set-Up

1. Give each player-pair one empty grid paper to work on together.
2. To start, the facilitator shows (on the board or a projector) row 1 of the encoded message, (e.g., 80) and gives a short time (e.g., 30 seconds) for partners to discuss what they think the protocol is (based on the intermission discussion).
3. Continue showing the player-pairs the rest of the encoded message, briefly, **one row at a time**.

Game Rules:

4. The player-pairs decode (fill in Black and White squares) each encoded message row into the empty image grid.
5. Then, if they can, they guess what the image is, and write it down beside the row they are currently working on.
6. Steps 3 - 5 continue 1 row at a time until the image is completed. Players can guess a new object as the image emerges.
7. Each player-pair gets 1 point for an accurately decoded row.
8. The pair that guesses the correct image first gets a bonus point.
9. The facilitator goes around to validate the accuracy of the image rows.
10. The pair with the most points wins this level.

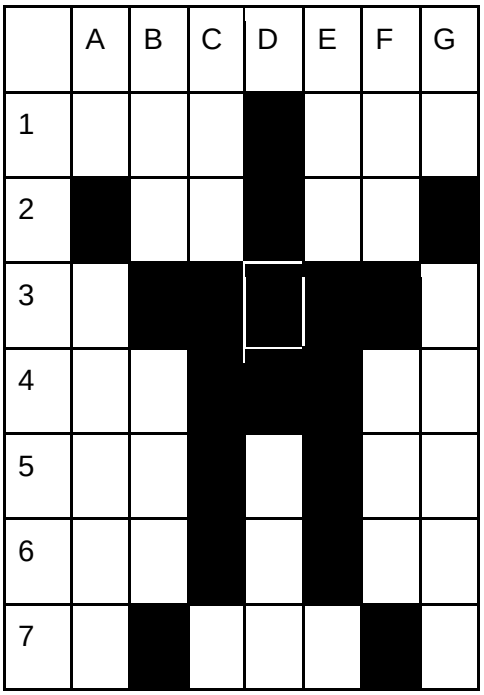
The rows may be timed with a short (30 sec for first row, and 10 sec for other rows) maximum time for each row to keep urgency going.

Level 3 - Game Level Overview (for discussion) (Encode Example with Run Encoding)

Level 3 is the reverse of level 2—from encoded numbers to an image, rather than from an image to encoded numbers.

Change partners so that strong and weak students move around. The facilitator will give each player-pair an image of pixels, that players will encode into a hidden encoded message of numbers.

Example of an Image provided:



Example Run Encoding Result: (not all _ have a character, because the rows are different lengths):

30130_ _
1201201
0510_ _ _
203120_
2010120
2010120
013010_

Level 3 – Encoding Messages
Set-Up and Rules

Give each player-pair one empty Encoded message (see below) paper to work on together.

Set-Up:

1. To start, the facilitator shows (on the board or a projector) to the players row 1 of the dots image and gives a short time (e.g. 30 seconds) to discuss with their partner the protocol that they used a few minutes ago (in level 2).

Rules:

2. The player-pairs are shown the picture images one row at a time .
3. The player-pairs encode each message row into the _ _ _ _ _ _ _ _ row, one numerical row at a time.
4. Then the partners guess what the image is and write their guess beside the current row. Players can guess a new object as the image emerges.
5. Steps 2 - 4 continue 1 row at a time until the image is complete.
6. Each pair gets 1 point for each row that is accurately encoded.
7. The pair that guesses the image first gets one extra bonus point.
8. The facilitator goes around to validate the accuracy of the encoded rows.
9. The pair with the most points wins this level.

The rows may be timed with a short maximum time (30 sec for first row, and 10 sec for each later row) for each row to keep urgency going.

Encoded Message:

_ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _

GAME WITH CONTEXT

Quick Matching Warm-Up

Students are newly minted humanitarian aid workers on a mission to help shepherd refugees of war safely from camps to safe houses and out of a very dangerous country. Communication in code is vital, since enemy soldiers are everywhere, and so the refugee camp is their primary station.

On day 1, there's not much time for training, except to use the matchup as preparation for real situations. Students will have to jump in and figure out the communications as they go.

Their first task(Introduction): Match an image with its coded number set. There is no rule book. The facilitator only has time to show them one example. Their brains will have to look for patterns and matches so that they can make the best guess possible out of the images provided.

After success: They have all passed the first test—a sink or swim situation to see if they have the ability to think for themselves under pressure. Quickly!

Level 1: Training Exercise to Determine "Level 1 Coders"

Context: The type of images in this situation could be:

- secret symbols that allow families to unlock and enter safe houses along their escape route
- iconic landmarks at the border or river crossings that mark the safe path to escape (like a hobo symbol)
- an escape route to take, and the locations of land mines around the route.
- four separate (unrecognizable) images that combine to make one image of a map with an escape route (for 4 students at same table in Level 1)

The new humanitarian workers have proven that they are good at recognizing patterns. Now, they'll have to show which ones among them will be coders (the winners of level 1) and which ones will be messengers (the non-winners of level 1, carrying but not making or breaking codes).

It's a competition on three levels for the coveted title of "master coder."

After Level 1 success: Congratulate the winners (half the group) and pair up a "coder" with a "messenger" to form the player-pairs.

Level 2: Real-Time Data, Incoming!

Explain that pairs are now going to work together, cooperatively, to decode real-time incoming data from agents in the field. The images from the field are constantly changing, for security's sake. The numbers are transmitted by secured radio transmissions, one row at a time. For added security and efficiency, a new protocol is used.

The accuracy and speed of decoding these numbers into an image directly affects the fate of the refugees and so everyone will work on the same images. Speed is of the essence! The first two player-pairs to accurately decode the numbers will receive the coveted "Level 2 Coder" rank.

After game success: Award the "ranks," congratulate the winners, and split them up to pair them with new partners. The goal is for everyone to learn from each other, so switching partners improves the overall speed and accuracy of the mission.

Level 3: Field Agents, Encoding New Images

The next mission is for all the coders, at all levels, to gain some field experience and use what they have learned to encode the newest images and transmit them back to camp.

Those images change every 24 hours! The faster they're encoded (and safe from prying enemy eyes), the more time families have to use them.

GAME WITH STORY

Story Overview: In a role-playing scenario, students are brand new humanitarian aid workers charged with helping scattered refugee families in three camps escape their war-torn land—alive!

The game play and context (described above) is the same, but with detailed narrative added:

FACILITATOR SCRIPT: Ongoing battles in Syria and Iraq have forced hundreds of thousands of families to flee north, through Turkey toward the safety of Europe, by truck, taxi, train, and even on foot. With only the possessions they can carry and little money or food, these families must cross many hundreds of miles of treacherous territory, across rivers, over mountains, and through massive barbed wire fences erected to keep them out. Along the way, they have no choice but to trust total strangers with their lives to transport them, to guide them, and to feed

and shelter them as their supplies dwindle.

These refugees on the move, more than 300,000 in number, are not entirely alone.

Humanitarian aid organizations are quickly recruiting people such as yourselves to assist in this unprecedented mass migration of displaced people. After an exhausting 20-hour flight, you have all just landed at the new Refugee Aid Command Center (RACC) in an undisclosed location in the Middle East.

You are assigned to the communications sector and will be trained on the job as coders and decoders of vital information. Always remember: this coded information is a matter of life and death. It includes passkeys to secret safe houses, maps of land mine locations, and icons that mark escape routes through hostile territory!

Your work begins immediately with the Pattern Recognition Aptitude Test (PRAT).

Given no rules or instructions, and only one very short demonstration, sink or swim, you are about to learn how well and how quickly your brain can detect and match up patterns of numbers with images, a vital coding skill. Think hard, do your best, and communicate with your team members for best results.

QUICK MATCH-UP ACTIVITY (as described above)

Level 1

FACILITATOR SCRIPT: Congratulations. Many of you have shown a remarkable natural aptitude for detecting patterns.

Based on the results, you will be paired up to determine who among you will be the master coders—the ones with the sharpest skills to code and decode highly sensitive information. That honor goes to the person in each pair who decodes a hidden image first.

Do your best!

From this moment on, refugee lives may be on the line! Stay sharp! Coding mistakes or other failures can lead a family to get lost, be captured by enemies, be deported or sent to displaced persons camps, or even die.

PAIR UP STUDENTS, PASS OUT LEVEL 1 MATERIALS

NOTE: For this story section and probably the context too, it would really help to add labels to the images to say what they are. For example, “Passkey image to unlock safe house.” And “Portion of a map with an escape route.” And: “Landmarks along safe escape route.” And the like.

FACILITATOR SCRIPT: You've each received a secret image, the form and nature of which only you know. Do not reveal this image to anyone .
Notice that the image is encoded in numbers, a way to conceal it from enemy eyes or dishonest dealers who take advantage of refugees. Your goal is to crack your partner's code and reveal his or her image first. Doing so will demonstrate your skills as a "master coder."
Your partner's image you must decode as quickly as you can by strategically guesses points on a grid. Follow these rules closely.

LEVEL 1 GAME (as described above)

LEVEL 1 SUCCESS OR MISTAKE(S)

1. **Land mine is falsely marked**: A pixel where there isn't a land mine costs valuable time to avoid. Since refugees risk getting captured the longer they are exposed and on the run, this mistake results in the capture of a refugee.
2. **Land mine not marked:** Much more serious—severe injury
3. **Perfect land mine map:** A family escapes death or injury, quickly, and proceeds to the mountain escape route, seeking safe houses for food and shelter along the way.
4. **One escape route error:** A refugee is deported by a border patrol—sent back to the camp to try again.
5. **Two or more escape route errors:** A family is ambushed and taken prisoner by the enemy.

FACILITATOR SCRIPT: Well-done, communications agents. It's time for a mission debrief: These four separate images need to be combined to make one image of a map with an escape route (for 4 students at same table in Level 1); All need to cooperate to reveal the escape route image.

Who among you succeeded in decoding your partner's image first? Congratulations. You are the "master coders" in charge of coding and decoding live information—real images and encoded data coming in from and going out to the field.

From this moment on, refugee lives may be on the line! Stay sharp! Coding mistakes or other failures can lead a family to get lost, be captured by enemies, be deported or sent to a refugee encampment, or even die.

[Pair up master coders with a non-master coder for the next level.]

INTRO TO LEVEL 2

FACILITATOR SCRIPT: Master coders and assistants, you must now work together to decode real-time data from agents in the field. Real-time means that agents are constantly transmitting number codes that, one line at a time, represent a vital image for refugee families to use—an icon to unlock a safe house door, for example.

You will notice immediately that the number protocol has changed, a measure taken for security's sake. The new protocol is also more efficient, allowing data to be transmitted at greater speed and security.

With each number code transmission, you will have a few seconds to discuss the number protocol with your partner and try to decipher what the image as a whole represents.

Remember: The accuracy of decoding numbers into an image will directly affect the fate of the refugees. Since you are decoding real-time data, in order to aid families who are on the run, speed is also of the essence!

Be fast, but be right!

LEVEL 2 GAME (as described above)

LEVEL 2 SUCCESS OR MISTAKE(S) - looking for Safe house (image and code)

1. **Erroneous safe house icon:** A refugee goes to the wrong house and receives no help, or is captured at an enemy house.
2. **Perfect safe house icon:** For each perfect safe house icon, the refugee is allowed in.

INTRO TO LEVEL 3

FACILITATOR SCRIPT: Master coders and assistants, you are now ready for the final challenge! Our scouts in the field are creating new classified images continuously. The safe house icons, the escape route landmarks, the land mine locations… These vital images must be encoded for secrecy's sake. The number codes will be then sent to agents who are helping refugee families; as you know, if they are imperfect or late in arrival, the consquences could be tragic.

Agents transmit these images one pixel row at a time. You will have a few seconds to encode each row into a number protocol and make notes about what the image as a whole might be. Accuracy is crucial; speed will be rewarded.

As before: Be fast, but be right!

LEVEL 3 GAME (as described above)

LEVEL 3 SUCCESS OR MISTAKE(S) - Encoding password for entry to Safe House

1. **Erroneous password for use at the safe house:** A refugee is not allowed to enter and is turned away, and receives no food or shelter.
2. **Perfect safe house Password:** , a refugee "unlocks" at the safe house food, water, shelter, and a cache of supplies.

FACILITATOR SCRIPT: Well-done, coders. You might be wondering about the fates of the families that you have assisted today. Let me share one true story:

Fatima, a 20-year-old from Damascus, Syria, escaped a violent ambush on a refugee camp where she was staying with her baby daughter and husband. With just seconds to pack up and flee, the family eventually managed to cross the border into Turkey. They stayed at a safe camp for a week and then jumped onto a rubber raft bound for Greece.

The Turkish police stopped the boat at sea and detached the motor to force the refugees to turn back. Instead, everyone on board steered the boat with makeshift paddles toward freedom. When they arrived, one man gave Fatima two jars of food and another handed her biscuits and water.

The family arrived with exactly these possessions, nothing more:

- Hat and a pair of socks for the baby
- Medication
- Bottle of sterile water
- A jar of baby food
- A small supply of napkins for diaper changes
- Aspirin
- Sunscreen and sunburn ointment
- Toothpaste
- Personal documents (including the baby's vaccination history)
- Wallet (with photo ID and money)
- Cell phone charger
- Yellow headband

"Everything is for my daughter to protect her against sickness," Fatima said.

*Refugee backpacks, unpacked: https://medium.com/@theIRC/what-s-in-my-bag-758d435f6e62 Survivor stories, with very little left to carry.

The Story Ends: After everyone has finished, announce that the images have each been passed along to a refugee family that will use the images to escape. Did the data help them survive and escape?

Final Result - Perfect escape route: A family makes it across the border and, if safe houses are identified and land mines avoided, and password is correctly encoded, then they are granted asylum in the neighboring country