

Using Systemic Communication to Improve Problem Solving

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Waters Grant Project

Interactive Fiction

Project Z

What is Zork?

Zork is a robotic character and you are its control central! This is an interactive fictional story where you help the character through its conflicts and take it through the story. You won't be able to help learning as you go, so put on that thinking cap!

Objectives:

General:

- Use context clues to identify new words
- Make inferences and draw conclusions
- Identify facts
- Follow written directions
- Make decisions and solve problems based on written information
- Read for information
- Transform written information to graphic data and back; mapping
- Develop vocabulary
- Summarize
- Synthesize
- Build questioning skills
- Work together as a class

Specific Literature:

- Cognitive strategy for finding critical questions in literature
- Literary analysis

Cooperative Skills:

- Stay with group
- Communication
- Participation by all
- Direct group work
- Express support
- Ask for help

REQUIREMENTS:

Groups must work together to gain points through the reading of Zork. Grade will depend on the following:

1. Accuracy of Group Zork Map (20)
2. Individual rough map (5)
3. Journal: * Records the exact place where you got your points and how
* Matches with the amount of points you have on screen
* Contains a running BOTG of your points by day
* Contains an entry for every RAAD discussion
* Can be used in any other helpful way your group decides on (You can use it to help keep track of where you leave items). (20)
4. RAAD discussion (10)
5. Communication and Collaboration with partner (10)
6. Communication and Collaboration with small group (5)
7. Game Points:
300 - 350 20 points
250 - 200 15 points
150 - 199 10 points

Total Points: 90

A+	98 - 100 points
A	94 - 97 points
A-	90 - 93 points
B+	87 - 89
B	84 - 86
B-	80 - 83
C+	77 - 79
C	74 - 76
C-	70 - 73

So, you may be asking, *How do I get an A or A+?* It's easy. For each group of four that completes the game in all of Ms. Dean's classes, every group will receive an additional point. Here's a tip, there will be anywhere from 18 to 21 groups of four. You do the math!

Good Luck!

INSTRUCTION MANUAL FOR ZORK

COMMUNICATING WITH ZORK:

In Zork, you type your sentence in plain English each time you see the prompt (>). Zork usually acts as if your sentence begins "I want to. . .," although you shouldn't actually type those words. You can use words like *the* if you want, and you can use capital letters if you want; Zork doesn't care either way.

When you finish typing a sentence, press the Return key and Zork will process your request. Zork will respond, telling you whether your request is possible at this point in the story and what happened as a result.

Zork recognizes your words by their first six letters, and all subsequent letters are ignored. Therefore, *Candle*, *Candles*, and *Candlestick* would all be treated as the same word by Zork.

To move around, just type the desired direction. You can use the eight compass directions: North, South, East, West, Northeast, Northwest, Southeast, and Southwest. You can abbreviate these to: N, S, E, W, NE, NW, SE, and SW. You can use UP (or U) and DOWN (or D), IN and OUT will also work in certain places.

IMPORTANT COMMANDS:

There are a number of one-word commands which you can type instead of a sentence. You can use them over and over as needed. Some count as a turn, others do not. Type the command after the prompt (>) and hit the Return key.

AGAIN: Zork will usually respond as if you had repeated your previous sentence. Among the cases where **Again** will not work is if you were just talking to another character. You can abbreviate **Again** to **G**.

BRIEF: This tells Zork to give you the full description of a location only the first time you enter it. On subsequent visits, Zork will tell you only the name of the location and the objects present. This

is how Zork will normally act, unless you tell it otherwise using the **VERBOSE** or **SUPERBRIEF** commands.

WAIT: This will cause time in the story to pass. Normally, between turns, nothing happens in the story. You could leave your computer, come back to it later and find nothing has changed. You can use **Wait** to make time pass in the story without doing anything. You can abbreviate **Wait** to **Z**.

THE GREAT UNDERGROUND EMPIRE:

ZORK understands many different kinds of sentences. Here are several examples:

**WALK NORTH
DOWN
NE
GO SOUTH
U
TAKE BOX
PICK UP WOODEN BOX
DROP IT
PUSH THE BUTTON
OPEN THE DOOR
EXAMINE THE SCUBA GEAR
LOOK BEHIND THE STATUE
LOOK UNDER ROCK
LOOK INSIDE CAULDRON
KILL THE BEAR WITH GUN
SHOOT BEAR WITH RIFLE**

You can use multiple objects with certain verbs if you separate them by the word **AND** or by a comma. Examples:

**TAKE LAMP, JAR, FLUTE
DROP DAGGER AND MACE
PUT GOLD BAR AND PEARL IN
CASE**

The word **ALL** refers to every visible object except those inside something else. If there were an apple on the ground and an orange inside a cabinet, **TAKE ALL** would take the apple but not the orange.

DIAGNOSE: Zork will give you a medical report of your physical condition. This is particularly useful if you have just

INSTRUCTION MANUAL FOR ZORK

(cont.)

survived a dangerous battle or if you are under the effects of a magical spell.

INVENTORY: Zork will list what you are carrying. You can abbreviate with I.

LOOK: This tells Zork to describe your location in full detail. Abbreviate with L.

QUIT: This lets you stop. If you want to save your position before quitting, follow the instructions in "Start and Stopping". You can abbreviate with Q.

RESTART: This stops the story and starts over from beginning.

RESTORE: This restores a story position made using the SAVE command. See "Starting and Stopping" for more.

SAVE: This makes a snapshot of your current story position onto your storage disk. You can return to a saved position in the future using the RESTORE command.

SCORE: Zork will show your current score and the number of turns you have taken. It will also tell you your rank, which is based on your score.

SAVING and RESTORING:

It will probably take you many days to complete Zork. Using the SAVE feature, you can continue at a later time without having to start over from the beginning. SAVE puts a snapshot of your place in the story onto the computer. If you are a cautious adventurer, you may want to save your place before (or after) trying something dangerous or tricky. That way, you can go back to that position later, even if you have gotten lost or killed since then.

To save your place in the story, type SAVE at the prompt (>), and then press Return. Follow the instructions for saving. Make sure you save it in your

period's folder.

You can restore a saved position any time you want. To do so, type RESTORE at the prompt (>), and press Return. Then follow the instructions. You can then continue the story from the point where you used the SAVE command. You can type LOOK for a description of where you are.

QUITTING and RESTORING:

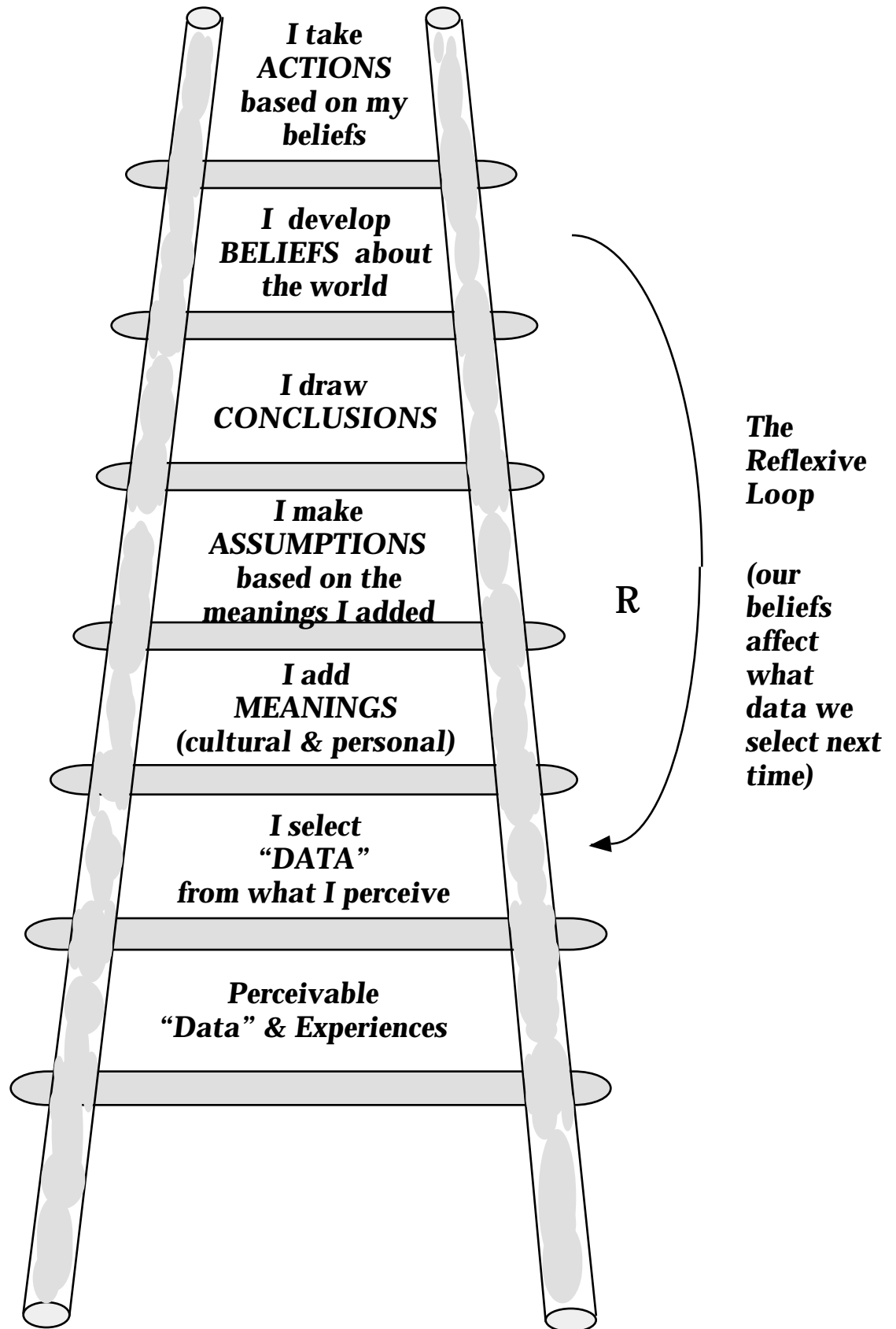
If you want to start over from the beginning of the story, type RESTART. Just to make sure, Zork will ask you if you really want to start over. Press Y for Yes and then Return.

If you want to stop, type QUIT. Once again, it will ask you if you are sure and if so, press Y for Yes and then Return. Remember, when you RESTART or QUIT, if you want to be able to return to your current position, you must first do a SAVE.

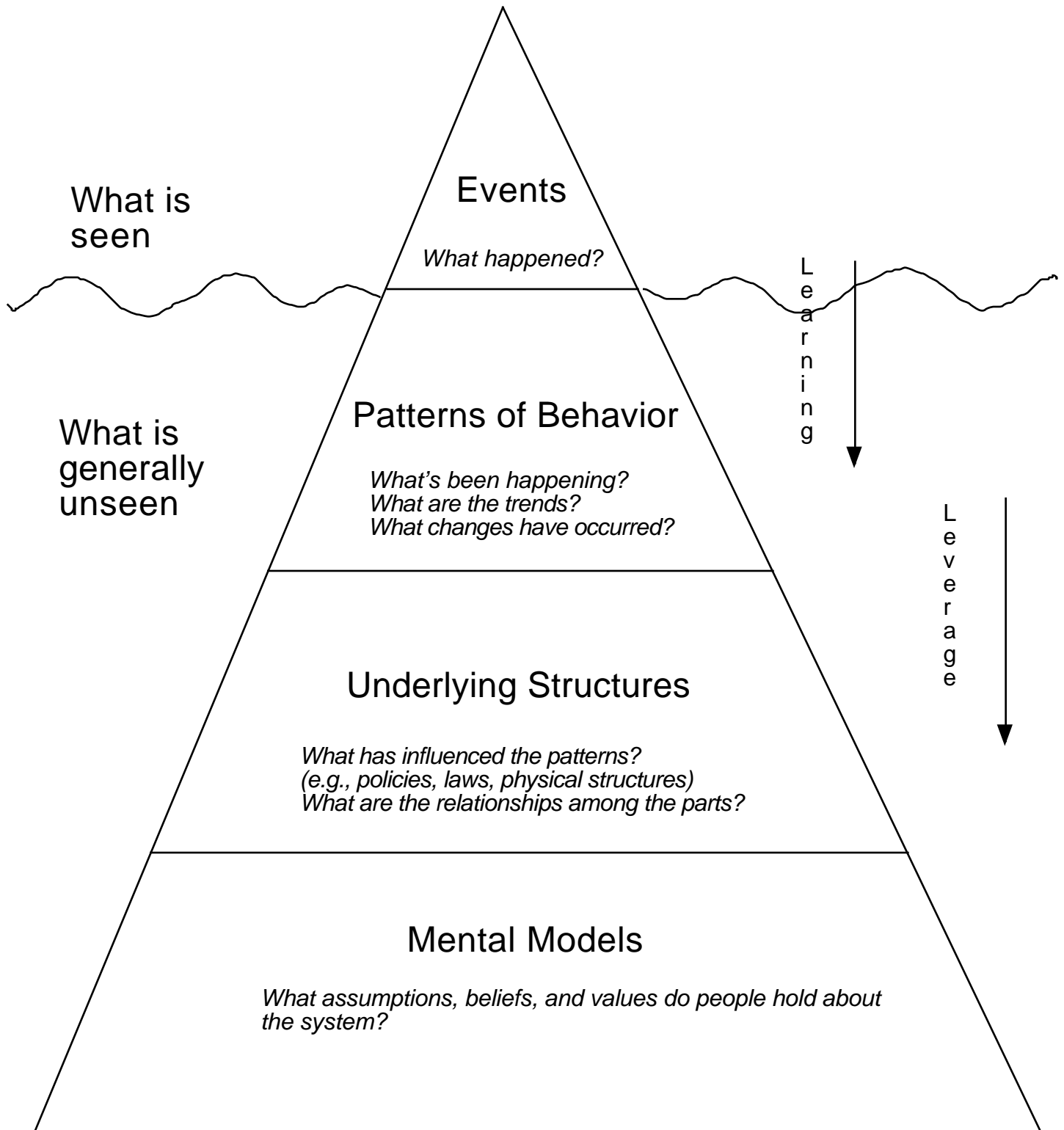
RECOGNIZED VERBS:

ANSWER	FOLLOW	SAY
ATTACK	GIVE	SEARCH
BLOW	INFLATE	SHAKE
BREAK	JUMP	SLIDE
BURN	KICK	SMELL
CLIMB	KNOCK	STAY
CLOSE	LIGHT	STRIKE
CUT	LOOK	TELL
DEFLATE	LOWER	THROW
DIG	MOVE	TIE
DRINK	OPEN	TOUCH
DROP	POUR	TURN
EAT	PRAY	UNLOCK
ENTER	PULL	WAKE
EXAMINE	PUSH	WALK
EXIT	PUT	WAVE
EXTINGUISH	RAISE	WEAR
FILL	READ	WIND

Ladder of Inference



Iceberg...Seeing What's Below the Surface



Two Modes of Group Communication

Skillful Discussion

Intending to:

- make a decision
- reach an agreement
- identify priorities

Involves convergent thinking

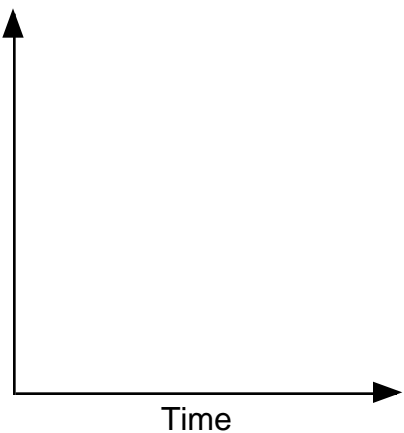
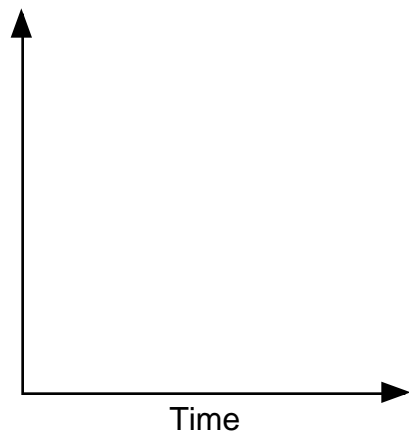
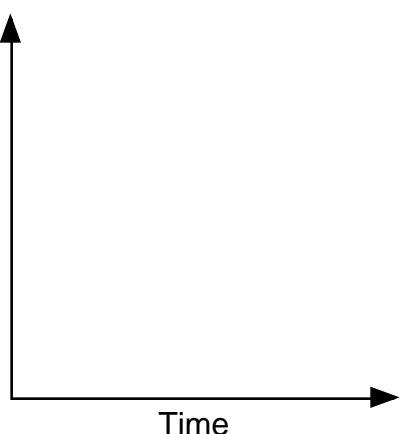
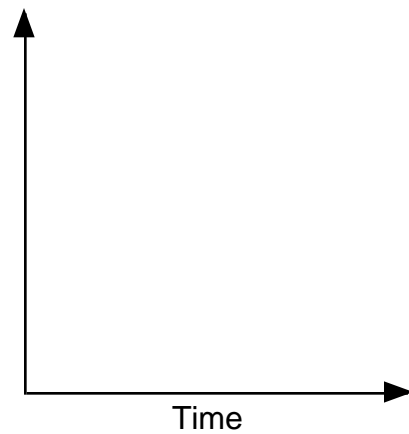
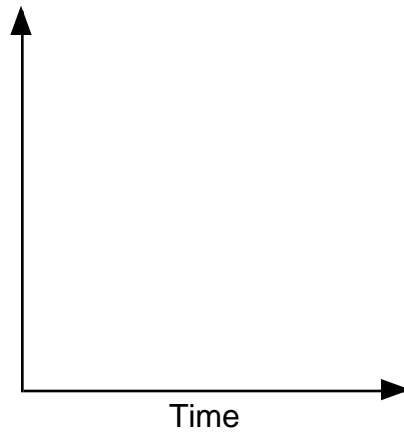
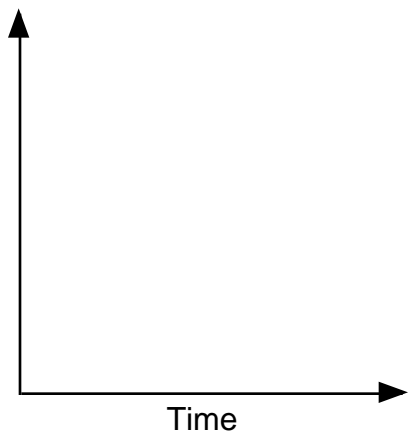
Dialogue

Intending to:

- explore
- discover
- gain insight

Doesn't necessarily involve convergent thinking

Behavior-Over-Time Graphs (BOTGs) (Trends vs. Discrete Events)



5-taking egg from tree
10-going inside house
5-putting egg in case
25-going down stairs in living room
4-taking painting from art gallery
6-putting painting in case
5-leaving troll room
10-taking platinum bar from loud room
14-taking torch from torch room
10-taking gold coffin from egyptian room
4-taking scepter from coffin
15-putting gold coffin in case
10-taking pot of gold at the end of the rainbow
6-putting scepter in case
10-putting gold in case
5-taking the scarab from the sandy cave
5-putting scarab in case
25-killing thief / going into the treasure room
10-taking chalice from treasure room
5-putting chalice in case
5-putting bar in case
4-taking trident from the atlantis room
15-taking the trunk of jewels from the reservoir
5-putting trunk in case
11-putting trident in case
10-taking skull from hades
10-putting skull in case
6-taking canary from the thief
1-taking the bauble from the tree
4-putting the canary in the case
1-putting bauble in the case
5-taking jade from bat room
5-putting jade in the case
5-taking the bracelet from the gas room
5-putting the bracelet in the case
13-taking everything out of the basket
10-taking the diamond from the machine room
10-putting diamond in case
10-taking bag of coins from maze
5-putting bag in case
5-opening the buoy
10-putting emerald in case
6-putting torch in case

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5-putting bag in case
5-opening the buoy
10-putting emerald in case

Egg

Painting

Platinum bar

Torch

Egg
Painting
Platinum bar
Torch
Gold coffin
Scepter
Pot of gold
Scarab
Chalice
Trident
Trunk of jewels
Skull
Canary
Bauble
Jade
Bracelet
Diamond
Bag of coins
Emerald

GARLIC
SCREWDRIVER
WRENCH
CANDLES
MATCHES
BLACK BOOK
LANTERN
PUMP
PLASTIC
SHOVEL
ROPE

Systems Thinking Used in a Middle School Classroom

Abstract: Systems Thinking is a concept that was based out of MIT and has been, initially, used for business purposes. For the past ten years, Systems Thinking has moved its way into our schools, and, as a result, students are learning higher level thinking skills.

This paper will address the question, *How can Systems Thinking be used as a way to get middle school students to understand the importance of communication and collaboration?* Life is a complex system. How well are students able to understand and operate in a complex system in order to increase productivity? Students will use Systems Thinking and Systems tools in order to help them better understand information, ask better questions, and think at a higher level.

What is Systems Thinking?

Jay Forrester, one of the founders of Systemic Dynamics, describes Systems Thinking as a way of looking at the world to understand better how the past led to the present and how present actions control the future. It's taking the parts and putting them into the whole to better understand how the whole works. A bicycle, for example, can be considered a system. It is made up of various different parts that, when put together, make a device whereby a person can hop on, pedal, and be on his way. Systems Thinking is not only looking at the parts that make up the whole, it is looking at how those parts affect one another to make the bicycle move. The trouble in education has been its failure to educate kids on complex systems. Educators are skilled at teaching the *parts* but many neglect to teach how those parts affect a whole (Forrester, 1993).

Systems Thinking involves using tools to help people understand the complexity of the whole; it helps people break down their ideas into logical possibilities. Systems Dynamics uses those tools and provides a philosophy of building on people's experience and knowledge in order to show how pieces of systems we know about are producing the behaviors that are so puzzling.

In education, Systems Thinking can be used to help organize detailed knowledge so that it becomes meaningful by giving real-life meaning to the parts. Too many times, students are asking what they are doing in school has to do with

knowledge so that it becomes meaningful by giving real-life meaning to the parts. Too many times, students are asking what they are doing in school has to do with anything. By teaching students Systemic Thinking early on, they will likely be reaching for the answer to that question on their own.

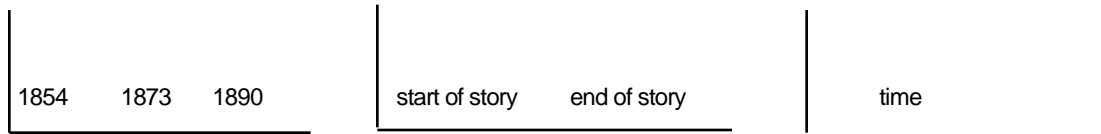
What are Systems tools?

There are many Systems tools one can use to expand understanding. Some of the tools that will be relevant to this paper are described below.

1. **Behavior Over Time Graphs** show the trend, or pattern of change, of a variable over time as opposed to discrete events.

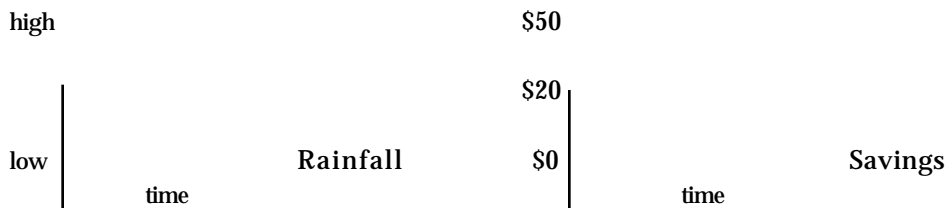
The X-axis:

- is always labeled time
- beginning, middle, and ending times may be indicated or not, depending on your purpose:



The Y axis:

- indicates the variable being graphed and must be labeled with that variable's name
- the label is particularly important when looking at graphs of different variables
- should not include qualitative words such as more, less, increasing, bigger, etc. in the variable's name; it's difficult to understand less "More fear" over time
- variable being graphed may be "hard" (like population or temperature) or "soft" (like love or stress).
- may be quantified as much or little as possible, or not at all:



If students/staff choose to graph more than one variable on the same graph, they will need to differentiate between the lines on the graph by including a key of some sort.

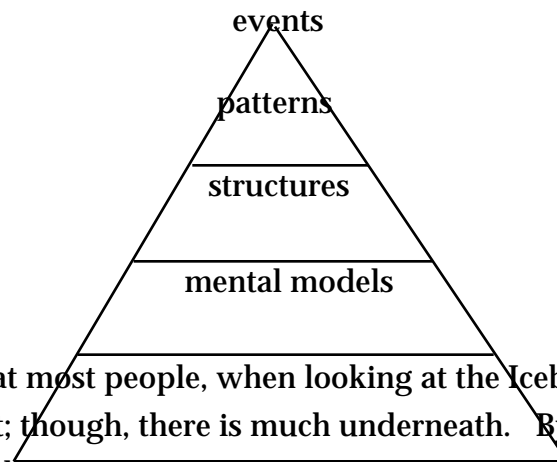
Different interpretations of the stated variable are definitely possible, although generally students' graphs of the same variable will look fairly similar. If they are

Different interpretations of the stated variable are definitely possible, although generally students' graphs of the same variable will look fairly similar. If they are radically different, discussion of the differences should take place, and could be very interesting!

Discussion of when and where a trend or pattern of behavior starts, ends, or changes direction is recommended.

When discussing the graphs of different variables, the graphs could be compared for possible interdependencies and causal relationships between the variables. (Brown, Richardson, Lyneis. 1998)

2. **The Iceberg** helps people use higher level thinking skills by having them look at the various levels of thinking. The Iceberg shows that most people see events fairly clearly. The next deeper thinking moves down to finding patterns between events. After one finds patterns in thinking, one can begin to narrow down the structures that make those patterns happen. The final and deepest level of thinking is the mental model stage. This is where a person has changed his or her way of thinking:



The idea is that most people, when looking at the Iceberg, only see what is apparent, the tip of it; though, there is much underneath. By using this metaphor as a tool, it can be noted that most people see the events and can label the events, but have great difficulty moving into deeper thinking. This tool helps people to see the different levels of their own thinking (Waters Foundation. 1997)

3. **The Ladder of Inference** is a tool used to help see the various levels of information that one can obtain. The Ladder helps determine which information is useful and which is superfluous. The ladder has seven steps that one will go through when learning how to make better decisions.

information that one can obtain. The Ladder helps determine which information is useful and which is superfluous. The ladder has seven steps that one will go through when learning how to make better decisions.

1. The first level on the ladder is “perceivable data and experiences.”
2. The second level is “selecting data from what I perceive.”
3. The third level is “adding meanings, both cultural and personal.”
4. The fourth level is “making assumptions based on the meanings added.”
5. The fifth level is “drawing conclusions.”
6. The sixth level is “developing beliefs about the world.”
7. The seventh level is “taking action based on beliefs.”

The ladder loops from the sixth level to the second when our beliefs affect what data we select next time.

The middle school experiment:

For many years, teachers have strived to teach kids the importance of meaningful dialogue and collaboration. Teachers have attempted to create effective group assignments where students interact with one another in order to problem solve. But, teachers still find it very difficult to transition that learning to real world problem solving.

This paper will deal with an experiment that was done in a middle school English classroom. The teachers set an “impossible” goal for students. They hypothesized that, with the use of systems tools, collaboration, and communication, the project, which would take an individual at least three months to finish, could be completed in two weeks.

The interactive reading game, Zork[©], was installed in fifteen computers (mostly laptops) around the classroom. Students were first assigned to a partner, someone they don’t normally interact with, and then the groups of partners were grouped with another partner group, forming a co-group of four. The partners would play the actual game and design their map and write in their journal as they went along. The co-groups worked together on one large map for the four of them. In playing Zork[©], it can take an individual up to three months to complete the game alone.

Earlier in the year, the students learned about effective discussion skills through Socratic seminars. Students would discuss teacher-generated issues while those on the outside would observe specific discussion skills, i.e. listening, questioning, involvement,

Earlier in the year, the students learned about effective discussion skills through Socratic seminars. Students would discuss teacher-generated issues while those on the outside would observe specific discussion skills, i.e. listening, questioning, involvement, leadership. At the time, students didn't know how relevant those skills would be in meeting their own needs later on in the year during the Zork project.

The Assignments:

Journal: partners keep journal of points, stating what they received points for and where. Students would also keep their Behavior Over Time Graphs in their journals.

Map: partners will keep rough map of Zork. The co-group will get together and design a final copy of Zork. They should label each room.

Socratic Seminar: students will get together to share strategies. One person from each partner group will be inside the discussion while the other person takes notes on the outside. Outsiders cannot join the discussion, and insiders cannot take notes. This forces partner groups to work together and establish trust.

At the end of the Socratic Seminar, the insiders formulate one question they want to ask the teachers. Answers are posted the next day.

The Beginning Behavior:

The first day, the students were allowed to explore the game on their own. They were given a list of commands that they could use to interact with the story. The story begins with informing the reader that they are standing next to a mailbox and they can see a house to the East and a path to the North. Students can explore by either typing: *open mailbox, go north, go east,* or other commands they would like to explore.

The students were told on the first day that, in order to receive a 90%, they must accumulate 350 points, the maximum amount of points one can receive in the game. Upon receiving 350 points, the game is completed. For every group of four that finished, everyone in all the teachers' English classes would receive an additional percentage point. Because the total number of groups of four was more than 10, students could receive a grade higher than 100%.

The students did not make a connection between the percentage points they

that finished, everyone in all the teachers' English classes would receive an additional percentage point. Because the total number of groups of four was more than 10, students could receive a grade higher than 100%.

The students did not make a connection between the percentage points they would receive and the process of playing the game. They basically wanted to do better than the next group. When students would find something interesting, they would, initially, keep very quiet about it.

The second day, students began to find out that they needed help. They remembered their co-group and began working with them.

The During:

Once students understood the importance of communication, and the use of filtering information through the Ladder of Inference, they began advancing through the game at a rapid pace. They began picking up skills to communicate in a more efficient and effective manner. Students were communicating with everyone they possibly could. Students began posting notes to the other classes, hoping to help other classes move along. When students had questions that no one in their class could answer, they created a "Questions" board where they would post questions.

Peter Senge, author of The Fifth Discipline, discusses the idea of building on the need for dialogue. Dialogue is a process of collective thinking and inquiry, a process transforming the quality of conversation and, in particular, the thinking that lies beneath it. Dialogue is difficult because it must stimulate free-flowing conversation. (Fulmer, Gibbs, Keys, 1998)

Students, without trying, began to dialogue. Students were talking to each other in order to solve problems the game presented; in their Socratic Seminars, students spoke freely to one another in order to gain the most information. Students were even caught discussing problems outside of class. The more they dialogued, the faster they began to get through the game.

How did students use the Systems Tools?

Ladder of Inference:

Students used the Ladder to help them organize information.

Because there was so much communicating, and so much information flying around the room at one time, students had to use the Ladder to help

Because there was so much communicating, and so much information flying around the room at one time, students had to use the Ladder to help them decide which information was worth using and which information was frivolous. Zork is a game where one decision that may appear to have short-term rewards ends up being a long-term problem. Students learned quickly not to believe everything they heard.

The Iceberg:

Students immediately saw events. When playing Zork, students can't help but to see events. In fact, they control events.

By using the Iceberg, students began to see patterns unfolding in the story. For example, every time their sword began to glow, trouble was ahead.

Moving to the structures that were in place in Zork became difficult for them. But through careful thinking, students began to see the structures that were in place that would help them succeed in playing the game. For example, in order to gain more points, the character in Zork must put his/her treasures into the trophy case in the living room. Light also became a structure for which they had to find solutions. Most of the game takes place underground. The character needs to find various means of light.

The Mental Models stage took place in their process of playing the game. They began to adopt the Mental Model that in order to be more productive, they needed to communicate with as many people as they could.

Behavior Over Time Graphs:

Students used BOTG's to graph their points. They would try to graph how many points they had at the end of each class. From this, they would begin to see patterns unfolding. They could also tell whether the strategies they were using were going to lead them to 350 points by the end of two weeks or whether they might want to re-evaluate their strategies.

The After:

The After:

After the two weeks, all but two groups finished the game. This was extraordinary in that it would have taken individuals, or even partners alone months to finish the game. Because the students worked together, communicated with each other by dialoguing, and used the Systems tools to sort information, they were able to finish the entire game in two weeks. Many groups finished after one week.

Students were excited. They had bonded together through their communicating.

When asked what helped them the most the students gave the following reasons: communication, journaling, mapping, and Systems tools.

The Final Assessment:

They were given a final exam where students were put with their co-groups and told that they must give the teachers the special objects in order to succeed. The teachers hid clues around campus and hid objects to which each clue would lead. In the end, every object had to be used in order to give the teachers the objects. For example, one object was a tape recorder, one a tape, another a set of batteries, a screwdriver, a box closed by a screw, and a combination lock box. Co-groups discovered that after they found their object that the only way to get anywhere would be to join other groups. Three groups got together to put the tape player together with the batteries and the tape. They played the tape and discovered a combination. They joined the group with the combination box and found an egg. Inside the egg, a note read: Teacher must have favorite candy. There was no candy. However, upon joining the last two groups and opening the box with the screwdriver, they found a strange piece of candy. When the entire class brought the candy to the teachers, it proved their success in working together and communicating.

How did Systems Thinking play a role in the students' learning?

If we revisit the Forrester's definition of Systems Thinking (a way of looking at the world to understand better how the past led to the present and how present actions control the future) and combine that with Senge's idea of communication (Dialogue is a process of collective thinking and inquiry, a process transforming the quality of conversation and, in particular, the thinking that lies beneath it) we can come up with a definition of Systemic Communication: A process of collective thinking and inquiry in order to understand better how the past led to the present and how present actions control the future. This idea of Systemic Communication was used in the Zork project

come up with a definition of Systemic Communication: A process of collective thinking and inquiry in order to understand better how the past led to the present and how present actions control the future. This idea of Systemic Communication was used in the Zork project with middle school kids. Students collectively learned the importance of communication in order to make better decision. The game became more than a grade for students, it became a conquest, something they were challenged to finish; something they desperately wanted to finish. Because of this, students learned intrinsically that in order to advance farther in tasks, smart communication with others is important. They learned that you can't believe everything you hear, you have to give a little to get a little, and your greatest resource is people.

Summary:

Through a middle school language arts class, the question in this paper addressed can be answered. So, how can Systems Thinking be used as a way to get middle school students to understand the importance of communication and collaboration?

By using various Systems tools, BOTG's, Ladder of Reference, and the Iceberg, students were able to filter through a mass of information to complete an impossible assignment. Without being told, students began to understand how to operate in a complex system in order to increase their productivity. By using Systems tools, students were better able to understand information, ask better questions, and think at a higher level.

When given the Zork final exam, where students had to actually play out the game in real life, students were quickly able to use the skills they acquired during the unit and complete the final with success.

The nice thing about Systems Thinking is that it doesn't just pertain to one subject or one field. Systems Thinking can be used in any occupation, any situation, and in school, any subject area. If people can be taught to be better thinkers in order to more successfully understand the parts that make up the whole and to see that whole as a big picture, than better decisions will be made, decisions that may have a positive affect on you or me in the long run. Our world is made up of quick fixes, short-term decisions with long-term negative consequences. If we can train people to think differently, to become Systems thinkers, then problems that are happening now as a result of decisions made long ago will cease to exist. The best place to train this type of thinking is at the educational level. And, it can start with any teacher, with any subject,

to think differently, to become Systems thinkers, then problems that are happening now as a result of decisions made long ago will cease to exist. The best place to train this type of thinking is at the educational level. And, it can start with any teacher, with any subject, with any type of student. The important thing is to get kids thinking.

Gordon Brown, Gayle Richardson, and Debra Lyneis. *Getting Started with Behavior Over Time Graphs: Four Curriculum Examples*. Vol. 7. No. 5. The Creative Learning Exchange, Late Fall 1998.

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Robert M. Fulmer, Philip Gibbs, J. Bernard Keys, *The Second-Generation Learning Organizations: New Tools for Sustaining,* Vol. 27, **Organizational Dynamics**, 1 Oct 1998.

Waters Foundation. CFSD from Innovation Associates, Inc. Sept. 1997.

<http://education.lanl.gov/resources/TEAM/Systems.html>

D R A F T

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1998-1999

by

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and

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