

# SEVEN ACTIVITIES TO ENGAGE SYSTEMS THINKING

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## Abstract

Seven activities to engage systems thinking are described, then discussed in a dialogue format. The seven activities involve the creation and discussion of (1) sets in contrast to systems, (2) a simple device to mix colored waters, (3) harmony in music, (4) storytelling, (5) playing in contrast to designing a game, (6) a language game, and (7) a strategy that selects in contrast to combines. Discussion relates systems thinking via these activities to education, human betterment, human systems inquiry, pedagogy, and technology.

Keywords: education, learning, pedagogy, systems thinking.

## 1. Introduction

The purpose of our paper is to describe and discuss seven activities in which persons can engage in and experience systems thinking. As a general source of further information about these activities, see Minati and Collen (1997).

Our paper consists of systematic coverage of each activity in turn. First, we describe the activity and second, pose for pedagogical application questions for discussion to foster reflection and consolidation of systems thinking as an experience and learning activity. Third, we discuss our views about the activity in a dialogue format, particularly in regard to such themes as informed decision making, general education, pedagogical strategy, human inquiry, and the use of technology. Our dialogue on this subject matter is especially intended to encourage more consideration of the relevance of systems thinking for education and pedagogy of our sons, daughters, and their peers---the next generation.

Regarding their application, the activities are not restricted to the order of presentation in this paper. They may be used in any order the pedagogue believes will implement their effective application. And each activity may be used alone. Although some of the

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discussion questions may seem to imply more involved discussion as the paper develops, it is not to suggest a delimitation to their application. Of course the questions may be modified and enumerated for every activity. Furthermore, the questions under one activity may prove helpful in discussion of another activity. Finally, our dialogue is intended to provoke especially those who would lead these activities. We believe that discussion leaders may find our exchange about systems ideas helpful to their planning and conduct of these activities.

### 2. Set and System

#### 2.1 Description of the Activity

Make two lists. One list has the overarching title “SET,” and the other list has the title “SYSTEMS.” Write out several entries under each title. For example, write down the *set* of ingredients to make a cake. Then write down what to do to mix and bake them so that they transform into a *system*. For another example, write down the *set* of your favorite football players. Then write down what they must do to transform into a football team. Compile two lists of several entries. Each entry has its *set* on one side and its corresponding *system* on the other side.

#### 2.2 Discussion Questions

1. What distinguishes a set from a system, and the converse?
2. What happens to transform a set into a system?
- 3.. What happens to change a system into a set?

#### 2.3 Dialogue

Arne Collen (AC): This activity really highlights the dynamic qualities of systems that are vividly absent in the more static qualities of set. It also can inform the player about the shift in thinking necessary to legitimate a system. That is, the salient elements one defines to initiate conceptually a system in thought is certainly one cognitive act, but it is comprehending the nature of their interactions that enables the player to understand them as a system.

Gianfranco Minati (GM): This activity helps the player to focus on the transformation process identifying the forces able to transform a set of elements into a system. Speaking about the elements of a set, what is easy to identify are the *relationships* among them. One element may be double another one in weight or in dimension and may come before or after another one regularly, and so on. Making reference to what you just said, the reference is to *static* relationships or having constant or predictable changing. The process of transformation into a system emerges when *interaction* among elements changes the properties of the set. The definition of interaction helps to identify the relevance of this point: we have an interaction among elements when the behavior of one modifies the behavior of another one. In systemics the reference is to *dynamics*.

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### 3. Mixing Colored Waters

#### 3.1 Description of the Activity

Fill three large glasses with colored water. Blue, red, and yellow food dyes may serve this purpose. Very slowly mix together in equal proportion any two colors on a plate or in an empty glass. Specifically, mix blue and red, blue and yellow, and red and yellow. Observe the changes in color swirls as the emergent color appears in the mixture. Now continue the procedure, but without duplication, using the six glasses. Mix only two different glasses at a time. The pairs should include the mixture of not only different colors (for example: blue-red with yellow), but also color repetition (for example: blue-red with red). Observe the changes in color. Finally mix in equal proportions the three original glasses of color, and observe the change in color.

#### 3.2 Discussion Questions

1. What can mixing colors tell us about the interactions of elements of a system?
2. How does a system create and destroy elements that do not at first seem part of it?

#### 3.3 Dialogue

AC: Given the rudimentary separation and paired mixing of colors, I do not think of this activity as engendering systems thinking per se, but it does help us to comprehend a stepping stone in the direction of systems thinking as well as bring into the foreground of our thinking the importance of emergence to systems thinking. Emergence is an important quality of systems, but is it an essential feature of only systems? When the parts interact, we can expect something more to come of it. At first, it would seem that the emergent quality is not present in a set. Perhaps we can think of it as a potentiality, should the elements of a set be made to interact. It is only through the interacting that the added feature becomes visible. Thus, this activity sparks some skepticism and wonder. By the mere mixing of two elements, in this case colors, can we say it is a system? Can an emergent phenomenon occur within a set, or is it a quality characteristic and reserved only for a system?

GM: I think the experiment helps the player to identify some crucial points relevant to systems thinking.

First is the difference between to add and to combine. Adding half liter of water to another half liter of water brings the result to have one liter of water. The reference is to *relationships* as it is to sets in the previous activity “Sets and Systems.” Mixing colored water means that the focus is on the process of mixing, watching the interactions among colors *while* they happen. The reference is to *interactions* as it is to systems in the previous activity.

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Second is the difference between reversible and irreversible processes. Systems may not be disassembled into parts, and systems time is irreversible. To go back in the time of a system, as to go back from a mixed color to the original ones, one must as before reduce it to a set of components, and then they may be modified, also activating reversibility. Time of relationships and time of interactions are different for many aspects. One regards the ability of the process to be reversed or not. A football team is a football team only when components play. Before and after is a set of players even if very oriented to become a system of players. The concept of subsystem may be considered as for transplants in living bodies. Subsystems may become components of a larger, hosting system.

Third is the role of observer. The observer is not just a detector of color, she or he is also a player. It is more effective in many fields to consider a system a *model* in the mind of the observer than an objectivistic property of a configuration. A system is recognized and continuously invented by the observer as it is for colors having physical evidence but “existent” only if used by an observer.

### 4. Harmony in Music

#### 4.1 Description of the Activity

With a musical instrument play separate individual notes. Now play the notes sequentially in various combinations. If possible play various combinations together. Listen for combinations that sound harmonious and others that sound cacophonous. Repeat the activity with others, in which each person plays a different instrument.

#### 4.2 Discussion Questions

1. Thinking of the musical notes as the elements of a system, what can the mixing of musical notes tell us about the generation of harmony and cacophony in a system?
2. If we imagine the notes, the instruments, each individual player, and the group of players as the essential aspects of the system, then what is the system?
3. What part does the listener play in the system?

#### 4.3 Dialogue

GM: We may refer to what has been discussed in the activity “Mixing Colored Waters.” But in this case certain aspects are to be emphasized.

First, when the same music is played by more instruments, may be the same kind of instrument, the expected effect is not to “play aloud” but to introduce some difference able to activate the reconstruction process by the listener. In Cognitive Science, it has been identified that to remember is not to find a memory of something in a warehouse but to rebuild starting from some elements and using the process that the human being has in

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mind. Recognizing and rebuilding colors and music correspond to this view (Minati, 1998).

Second, the central role of the observer is emphasized. The observer generates meaning from the inputs and outputs. They may be used to *induce* the kind of memory the sender has in mind. Interactions among notes are the key points as it is with the mixed colors.

And third, the source of the music is a *system* itself, because the human being uses interactions among instruments, players, listeners, and acoustics of the environment itself, in order to *induce* a message, to make it *emergent* in the listener. We may appreciate how an orchestra is a system when the players synchronize and tune instruments and themselves before playing, using the instruments and looking in each others eyes to be harmonious. They must be harmonious if they have to produce harmony.

AC: This activity about harmony in music provides an even more experiential and sophisticated appreciation of system than the color mixing activity, because the participants are freer to play and innovate much more creatively. The discovery of harmonious and cacophonous sound combinations is often quite striking. The interactive nature of the activity is enhanced substantially in my opinion when done with others. One quickly appreciates the nature of a human activity system that is a band, vocal group, choir, and orchestra. It takes little imagination to translate the sounds of instrumental music to other kinds of sounds (e.g. talking, chatter, party conversation, city noises, remote nature settings) as other contexts where the “music” reflects the activity of the system. It informs us we are amidst and part of a living system.

Additionally, the participants can use this activity to grasp and discuss classic concepts associated with the general theory of systems (Bertalanffy, 1975), such as equilibrium and disequilibrium, as parallel to harmony and cacophony, respectively. By way of a second illustration, choices to play, variations of a musical score, as well as the varied experiences themselves, noted by both players and listeners, of the group playing the same piece a number of times together bring to import the theoretical notions of the equipotentiality and equifinality of a system.

## 5. Telling Stories

### 5.1 Description of the Activity

Before the story can be told, several prompts must be written. A prompt is a short phrase, which informs the story teller to tell the next part of the story. Some examples of a prompt are: she talked about; he got into the car; she received a letter. With several prompts in one order, tell a story. Shuffle the prompts and tell another story. Continue the activity to create several stories with the same prompts.

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### 5.2 Discussion Questions

1. Is to tell a story to describe a system?
2. What can a story tell us about the system of human beings?
3. In what ways is creating a story like a system of human beings making a decision or completing a project together?

### 5.3 Dialogue

AC: This activity can be quite provocative and profound for the story-teller, having created several stories from the same prompts, after which trying to make some inference to systems thinking. The listeners also can appreciate the versatility and variety of interactions possible from the same linkages. They can see the creativity engendered by a rudimentary set of linkages among the elements as the story weaves together to become more and more into a whole. Both the teller and listeners experience the vitality of the composing, bringing a sense of unity and integrity to the whole. But importantly and not so evident from the previous activities we have discussed, story-telling brings together and unites into a system the teller and the listeners. The event bonds them altogether to become one kind of human social system. Perhaps, herein lies the heart of our pursuit to engage in systems thinking.

GM: We may figure out this activity using the technology of hypertext. The key point is to create connections using the available elements, in this case parts of stories. Generally speaking, it is what we do with natural languages using, that is *connecting*, words. We may appreciate how creativity is based on dialectics between elements and usage of the elements themselves. Speaking about natural languages on one side, we have words and syntax (rules about how to connect them), and on the other side, we have semantics based on the usage of words and rules.

AC: The challenges of studying and describing a system become more apparent when we consider the story as an analog to the description, model, plan, or design of a system.

GM: This example is very good to appreciate the central role of the human being in creating meaning. The activity of designing a system, such as a story, cannot ignore *who* is designing the system and for *whom* the system is designed (the clients, the stakeholders). Furthermore, the global context must be taken into account, in other words, the time *when* the system is designed and the space *where* it is designed.

AC: The perspectivistic nature of the activity of story-telling comes more to the foreground, because it is of course the perspective of the story-teller. Each story-teller gives his or her own slant to the same story, just as each stakeholder, constituent, participant comprising the system has his or her own view of what is and is happening in the system.

GM: In my opinion this activity should be used more as a game than to illustrate analogies and analytical analysis. The focus is on the active, autonomous role of the

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story-teller who is not expected to tell something right or wrong but amusing and interesting.

### 6. Playing and Designing a Game

#### 6.1 Description of the Activity

Select a liked and familiar game. Review the rules of the game with the other participants. Play the game. Discuss the rules and make a group decision to alter the rules. Allow each person to contribute one alteration of the original rules. That is to say, create a new variation of the game by changing, adding, and eliminating rules. Play the new version of the game.

#### 6.2 Discussion Questions

1. What does having a set of rules tell us about the way a system works?
2. What is the difference between playing a game and designing a game?
3. What is different about the system when the game is being played and when it is being designed?

#### 6.3 Dialogue

AC: Although disguised in the form of a game, I think this activity is about comparisons and contrasts between playing and designing. The nature of the activity can be dramatically different. Perhaps the best way for me to anchor the point is by reference to a two tier learning process, notably pointed out as single and double loop learning (Argyris *et al.*, 1985), first and second level cybernetics (Foerster, 1981), and mono and deuterio learning (Bateson, 1972). Playing the game is to be immersed in the act of performance of turn taking according to the set of rules, whereas designing the game involves not only playing it, but also engaging in a higher order cognitive skill of reflecting upon the possible alterations and their consequences of playing according to the alternations. Certainly, a skilled player exercises the pragmatic nature of game playing heavily in planning moves and anticipating the moves of other players, suggesting application of both tiers, but designing requires a comprehension of the holistic and systemic view of the game itself, which the players need not reflect upon while playing the game.

GM: Interestingly enough, we may compare this activity with a previous one “Telling Stories” we discussed earlier. The central point is the *usage* of what is available and not just to focus more and more on the same kind of usage. As we already said the activity of creating a game is based on *who* is inventing and for *whom*. That’s why we have different games. That’s why different rules. We use the same tools designed for different people, such as children, and different occasions, such as to learn just for amusement.

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AC: Yes, we can view story-telling as a kind of game. It can become a game. And we can discover the rules and variations through repeated occasions of telling the same story. For example, I remember the fun it was to be a boy scout in the United States in the 1950s. On one camping trip in particular, I remember when our group huddled together in a tent at night during a rain storm, taking turns telling ghost stories. Each one of us tried to out do the others by telling a similar but scarier story. The stories formed a set in my mind, governed by a set of rules, variations of which generated more and more scarier, wilder, and imaginative stories. Harking back to our activity “Sets and Systems,” it was through activities such as story-telling, playing such games, that I and my fellows scouts came to think of us as a clique. It was from these experiences I reaped the meaning of being a boy scout and being part of a system. It was through these collective activities that the group became more than a set; we became a more visible and real human social system.

GM: Making reference to the experience you just told, I remember when I was a child and playing with other children. We felt free to select among three possibilities: (1) play a game with rules arranged in advance; (2) change some rules depending on the context, such as how many players, where the game is supposed to be played, difference in age among the participants, and difference between boys and girls; and (3) invent a game. At this age we felt we were a group by how much we managed continuously the variation among the three possibilities. We considered the game with rules arranged in advance as the starting point for the game as a process to combine the definition of rules and the playing activity. Then I discovered the age in which we are expected to play *well* defined games, such as chess, student, worker, husband, father, and so on. The comparison is always the same: rigidity vs. rigor, that in systemic language means closeness vs. openness and deduction vs. induction. The crucial point is not that one is better than the other, but both approaches must be managed and used.

### 7. A Language Game

#### 7.1 Description of the Activity

The game is best played with another person whose primary language is your secondary language. Select a word or phrase of your primary language and translate it into your secondary language. For example, if Spanish is your first language, you might translate the material into English as your second language. Ask the person to back translate your translation, that is to say, translate the English back into Spanish. Exchange places and allow your partner to present a translation and you back translate. Continue alternating back and forth rounds of the game until each person has completed several words or phrases. Examine the results. Observe the differences in meaning between the original words of the primary speaker and those imparted by means of back translation.

#### 7.2 Discussion Questions

1. Of what importance is language in a living system?



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2. What can happen when two systems, that have different languages, must communicate?
3. What problems can arise when two systems with different languages must communicate?
4. What solutions might solve the problems that can arise when two systems with difference languages must communicate?

### 7.3 Dialogue

GM: The theoretical side of this game is well illustrated by the problem of *translating* and more in the last decades by the problem of *automatic translation* in Artificial Intelligence (AI). The ability to “move” into a space of languages *keeping meaning* is a matter of creativity as is translating. By the way, it is why a translation has *always* an author (collective authoring is possible) and is copyrighted. The idea to make “translating” automatic may induce the idea that this activity is possible independent of the human being, that is machine performed. Thanks to the approach realized in Cognitive Science, this is a naive, ineffective and contradictory idea, because translating is a peculiar creative activity of the human being; it has been changed into the need to use supported translation, which is supported by models of the translator processed in computer systems.

AC: Certainly, language serves our needs to communicate with our fellow human beings. In congruence with this activity, what I mean by language is the spoken as well as the written word. It seems that with continued advances in communication technologies we are becoming more dependent on spoken and written language to communicate with each other, compared to other forms of communication, for example, gesture and physical contact. The matter of translation gains importance all the more today, because of the increasing proportion of our activities channeled through telecommunications. As the human world becomes the globe it seems, and the globe becomes increasingly more to comprise vast networks of persons telecommunicating, this game of translation and back-translation reminds me how evident it is that the languages-of-humanity is a system and human languages are intertwined and interdependent subsystems of a vast global communications network.

GM: Making reference to the first discussion question, as a great logician Wittgenstein (1889-1951) wrote that it’s impossible to think of a language without thinking of the living beings using it. Language characterizes living beings. We have to consider the differences among (1) *natural* languages as generated and used in time and space by living beings, and (2) *formal* languages used to make machines able to communicate among themselves and human beings, and to produce knowledge having *objective* validity for anybody, having no ambiguity, as in mathematics, physics and jurisprudence. The processing expected by the receiver must be considered. Language is a system when it is used by a living being. A book, a paper, a song, a phone call, a television program, and a movie are not systems by themselves. The human beings involved must be considered, both sender and receiver. Different levels of interactions among the human

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beings involved may be considered, and that makes reference to the concept of *openness* in systemics.

AC: There are many problems among peoples today spurred expectantly by our heightened international mobility and telecommunications. We increasingly inhabit the same time and space. Communication problems are fertile ground to apply and discuss this activity to deepening our understanding of our world as a global system of many languages. Unlike most of the activities we discuss, this one brings needed attention to this central area of human affairs.

Perhaps akin to the “Telling Stories” activity, this one lends itself nicely to the more psychological aspects of our being. This activity may be used to discuss the importance of sympathy, empathy, respect, diversity, and tolerance of others as emergent qualities in human relations that appear playing this language game with others whose language and culture differ markedly from one’s own. Importantly, the topic of human rights issues may be broached in discussing their relevance to language usage and translation.

Finally, I wish to add that although difficult for most of us most of the time---preoccupied legitimately as we are with personal local matters---nevertheless for all of us, we must recognize and understand the more far-reaching consequences of our actions, and eventually accept a shared responsibility for a global ethic. I think such a far-reaching vision may be suggested and even fostered through this activity.

## **8. Selecting and Combining Strategies**

### **8.1 Description of the Activity**

The idea of this activity is first to define several ways to engage in the activity, and second to compare the experience of doing it only one way with doing it other ways. The idea is to combine ways to create alternative and perhaps more expedient ways of doing the activity. The activity may be done in solo, but with one other person, even a small group, it provides the context to share experiences and discuss the activity. The exercise works best with solving a problem, playing a game, or performing a task. For example, if the problem is signature recognition, does it seem to work better to examine only the slant of the letters, or concentrate only on the curves of the letters, or combine strategies? If the game is chess, is it better to select one of a dozen established strategies and systematically play out the game holding to the selected strategy, or develop one’s strategy from among known strategies as the game progresses? If the task is to walk through the market to buy all the items on your grocery list, will the floor plan, section signs, or density of shoppers determine your chosen strategy; in other words, which strategy defines the route, or can a combination of strategies ensure all items on the list will be obtained?

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### 8.2 Discussion Questions

1. Do combinations have any advantages over specific selections?
2. In a living system, under what circumstances might a selection be the better choice?
3. In a living system, under what circumstances might a combination be the better choice?
4. In what ways are selections and their combinations relevant to systems thinking?

### 8.3 Dialogue

GM: This activity provides a good example of the effectiveness of using different strategies and resources, combining them, than on trying to select the best one and applying it all the time. Having one strategy to make it more and more effective and powerful is done by the use of the five senses by a child in the very early years of life. The early years are not used to select the best sense, rather to focus only on it and to improve it. As studied in Cognitive Science, this approach produces not only rigidity but also pathology.

AC: Here is quite a confluence of human communication, development, psychopathology, and strategy! The theoretical work of Ford and Lerner (1992) and clinical contributions of Watzlawick *et al.* (1967) immediately come to mind. But let me focus for the moment on human intelligence. Engagement in this activity requires some intelligence. One might expect any species that displays strategizing, and acquires increasingly more sophisticated action sequences from strategizing, demonstrates a marked degree of intelligence. Certainly, this notion has led to rationale for AI, leadership training, and research into human and animal learning. But to our purpose here, this activity to engage systems thinking highlights a feature of human activity that the other activities cannot immediately evoke.

GM: Learning how to use available resources, how to combine them, how to process information from different sides, and having each one a different meaning, is a systemic view of information processing. Based on not only the ability to reproduce meaning that is decided by the sender and apply it directly, but also the process altogether, this strategy may be well implemented in AI with the technology of neural networks using a superior layer, where inputs are evaluated and used. A good example in Cognitive Science is the difference between to retrieve and to reconstruct a memory; in the first case memory is considered just a storage, and in the second case, it is an active process.

AC: Although I can connect this activity, as you do, to AI and Cognitive Science (Minati, 1998; Vallée, 1995), it continues to interest me that, like the other activities we have discussed, the one who does the strategizing can reach a place in his or her thinking where an insight occurs. The person knows that the various strategies form a conceptual system. It is a system that also includes the process of using them, that is, being in and acting upon ones world. Of course, this system takes years to develop, and as we know, it can get brilliantly as well as pathologically sophisticated. In my fast-paced world, I must have an agility and repertoire of action sequences to handle a multitude of situations and

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available resources. As a strategizing participant in life, this activity brings into the forefront for me, and I would presume for those who partake in this activity, one of the more dynamic facets of systems thinking.

### 9. Conclusion

Systems thinking is a dynamic process of human activity, difficult we find to capture in any one descriptor or activity. There are a number of activities to experience one or more aspects of the process. We have presented seven, which convey the richness and diversity of the construct. We think of them not as a set, but as a system that enables us to comprehend human nature more fully.

From set to system, we move from body to being. From mixing colored waters, we emerge cognizant of formerly invisible properties. From harmony in music, we embody collaborative, cooperative, and collective action. From telling stories repeatedly, we deepen the bonds that unite us. From playing then designing a game, we shape our future. From a language game, we take our awareness below the surface of others. And from selecting and combining strategies, we better our condition in life. In pondering these statements keep in mind that we think them clearly incomplete and impoverished characterizations of each activity. Each activity typically engenders multiple aspects of learning about systems thinking.

Through our descriptions, discussion questions, and dialogue, we have tried to show directly that there are numerous activities available to study, understand, and apply aspects of systems thinking. Indirectly, we have tried to show the relevance of the activities to not only systemics, but also everyday life. We would hope ideally for their applications to create connections among the many peoples, cultures, language groups, occupations, professions, disciplines, and fields of study.

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