Systems Thinking: A Key 21st Century Skill in K-12 Education

Andrea Davidson and Joan Yates
Catalina Foothills School District
Waters Foundation
Tucson, Arizona
During this session, we will:

• Explore a district’s evolution of its essential 21st century skills
• Analyze the commitment to systems thinking as a 21st century skill
• Examine systems thinking’s place in core content
• Explain available professional development structures
• Experience 21st century covariant curriculum by applying ST rubrics to student work samples
• Summarize basic dynamics that increase student achievement
Evolving 21st Century Skills

Digital Age Literacy
- Basic, Scientific, Economic, and Technological Literacies
- Visual and Information Literacies
- Multicultural Literacy and Global Awareness

Inventive Thinking
- Adaptability, Managing Complexity, and Self-Directed
- Creativity, Imagination, and Risk-taking
- Higher-order Thinking and Sound Reasoning

Effective Communication
- Listening, Collaboration, and Interpersonal Skills
- Persuasion, Social and Civic Responsibility
- Productive Communication

High Productivity
- Plan, Manage, and Manage for Results
- Effective Use of Informational Tools
- Relevant, High-quality Products

Academic Achievement

By NCREL/Metiri Group
Our Commitment to Learning in the 21st Century

21st Century Learner

Core Academic Subjects

Learning & Thinking Skills
- Data Analysis
- Systems Thinking

- Scientific Inquiry
- Critical & Creative Thinking

Technology & Tools
- Digital-Age Literacy
- Core Academic Subjects

Global Awareness
- Cultural Competence
- Interactive Communication

Self-direction
- Productivity
- Teamwork

Leadership
- Personal & Social Responsibility

Catalina Foothills School District

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I am CFSD

Play Creative and Critical Thinking Video

Play Hydrology Project Video

Play Cultural Competence Video
21st Century Skills in Field Studies
Events
What happened?

Patterns of Behavior
What’s been happening?
What are the trends?
What changes have occurred?

Underlying Structures
What has influenced the patterns?
(e.g. policies, laws, physical structures)
What are the relationships among the parts?

Mental Models
What assumptions, beliefs, and values do people hold about the system?

Iceberg... Seeing What’s Below the Surface

What is seen
What is generally unseen

Leverage
Learning

Adapted by Waters Foundation, CFSD from Innovation Associates, Inc. 2/99
Systems thinking is a vantage point from which one sees a whole, a web of relationships rather than focusing only on the detail of any particular piece. Events are seen in the larger context of a pattern that is unfolding over time. Systems thinking provides students with a more effective way of interpreting the complexities of the world in which they live—a world that is increasingly dynamic, global and complex.

Level 1: Students identify and consider the interdependent parts of problems or issues.

Level 2: Students analyze causal factors and evaluate the consequences of decisions in the short- and long-term.

Level 3: Students design or improve a system by determining the leverage point(s) at which change can have the greatest impact.
Habits of a Systems Thinker

- Observes how elements within systems change over time, generating patterns and trends.
- Identifies the circular nature of complex cause and effect relationships.
- Seeks to understand the big picture.
- Changes perspectives to increase understanding.
- Checks results and changes actions if needed: “successive approximation.”
- Surfaces and tests assumptions.
- Considers an issue fully and resists the urge to come to a quick conclusion.
- Considers how mental models affect current reality and the future.
- Uses understanding of system structure to identify possible leverage actions.
- Considers both short and long-term consequences of actions.
- Finds where unintended consequences emerge.
- Recognizes the impact of time delays when exploring cause and effect relationships.

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## Systems Thinking Rubrics

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<td>Big Picture</td>
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<td>Interdependencies</td>
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<td>System-as-Cause</td>
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<td>Change over Time</td>
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<td>Leverage Actions</td>
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[Image of rubrics with icons representing each category]
9. Patterns of Change Over Time

Students will describe and compare characteristics of economic activities, political activities, migration, ..., and major world regions. They will analyze how individuals and societies have changed and interacted over time. They will interpret significant patterns, themes, ideas, beliefs, and turning points in history. Throughout the world, people are increasingly linked by physical and human systems. Interdependence can be better understood through the study of events that have significance beyond regional or national boundaries.

CFSD Social Studies; 6/07 - Approved by the CFSD Governing Board, 11/28/06
11. Critical and Creative Thinking
Students will analyze issues by tracing their origin, framing and testing hypotheses, considering various perspectives, and evaluating possible ways to resolve the issues. Meaningful understanding of the past involves the integration of historical knowledge and thinking skills. If decisions in contemporary life are to be guided by knowledge of the past, students must learn how to engage in historical reasoning, think through cause-effect relationships, reach sound historical interpretations, and conduct historical inquiries.

CFSD Social Studies; 6/07 - Approved by the CFSD Governing Board, 11/28/06
4. Economic Philosophies and Systems  
SS4.7.4 Describes the causes and effects of economic instability (required: hyperinflation in Germany, inflation, Great Depression in America, New Deal, rising prices and interests rates, unequal distribution of wealth).

9. Patterns of Change Over Time  
SS9.7.3 Explains the impact of war on economic instability, recovery, and growth (for example: war bond drives, war industry, women and minorities in workforce, rationing).

11. Critical and Creative Thinking  
SS11.7.3 Examines historical events, problems or issues by analyzing the parts of a system (for example: branches of government, Stock Market, Great Depression) and the manner in which they interact.
3A. SYSTEMS THINKING: BIG PICTURE/INTERDEPENDENCIES
SC8.3a.1 Creates a model of key interdependent relationships by taking a whole-system perspective on an issue or process (for example: in the area of genetics - drug resistant bacteria).

3B. SYSTEMS THINKING: CHANGE OVER TIME
SC8.3b.1 Describes a system component’s continuous pattern of change over a specified period of time (for example: adaptation of an organism’s survival in a desert ecosystem with increasing aridity).

3C. SYSTEMS THINKING: LEVERAGE
SC8.3c.1 Explains what critical variable within a system produces the most leverage toward a desired change (for example: when to apply a force to get desired acceleration).
Professional Development Structures

- Teacher-Leaders as mentors to colleagues
- Collaboration through data teams
- Waters Foundation’s WebEd
- PD courses
- 21st Century Student Achievement Plans
- Shared systems thinking lessons
Assessing Student Work
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  - Projects a behavior into the future based on current trends.  
  - Identifies and explains the difference between changes in accumulations over time and the rates at which they change.  
  - Identifies, describes and distinguishes between changes in qualitative (e.g. happiness) vs. quantitative (e.g. population) entities that change over time. |
| Representations               | Represents events, e.g. lists a sequence of events.                    | Represents change as event-based, e.g. dots connected on a graph.     | Represents continuous change over time, e.g. on a line graph.                                                             | Represents continuous change over time of more than one variable, e.g. on a line graph.                                      |
| Transfer                      | Does not attempt transfer.                                             | Attempts to transfer understanding of an identified change-over-time to a non-transferable situation. | Transfers understanding of an identified change-over-time by comparing it to a situation of a similar type, e.g. perseverance over time for two characters in different texts.  
  - Identifies similarities and differences between the two patterns of change. | Transfers understanding of an identified change-over-time by comparing it to a situation of a different type that operates in a similar manner, e.g. a fictional character’s perseverance over time compared to that of an historic figure.  
  - Identifies similarities and differences between two patterns of change and explains why the similarities and differences exist. |
Classroom Climate - Feelings about the school day

When it is Morning Circle, Stories and Writing and Workshop I like it. In P.E. I sort it. At Lunch, DEAR, Investigations and Choices I like it. Closing Circle I don't leave.
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<td>• Recognizes and explains some interdependent elements of a system including accumulations and flows with at least one feedback relationship.</td>
<td>• Recognizes and explains how the structure (interdependent elements) of a system including key accumulations and flows, relevant boundaries, inherent time delays, and balancing and reinforcing feedback produces particular behaviors over time.</td>
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<td>• Represents some interdependent relationships affecting accumulations but emphasizes a list of influencing factors.</td>
<td>• Represents the underlying structure of a system operates and produces particular behavior(s) over time.</td>
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Charlemagne made Emperor

Fear of Charlemagne

Conquered Lands

Losing

Armies

Forming

Strength of Empire

Increasing

Decreasing

Less protection

Charlemagne's Death

Dividing Empire

Quarreling
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<td>• Identifies and explains causality in a system as an ongoing reinforcing or balancing process with effects feeding back to influence causes, and causes possibly affecting each other.</td>
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<td>• Represents causal feedback among three or more elements of a system and/or creates interconnected multiple loops. • Represents causal feedback relationships as either reinforcing or balancing. • Describes how two or more interdependent feedback loops are comparatively more or less powerful over time.</td>
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Chemistry - Water Quality

Students discover this balancing relationship as they participate in the water quality simulation.
An example from The Netherlands

- Connection Circle
Classroom/School Climate - Friendship Skills
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<td>Identifies at least one leverage action in a given historical or current system. Given a challenge, uses understanding of system structures to identify and explain possible leverage actions.</td>
<td>Identifies possible leverage and non-leverage actions within a specific system. Given a challenge, uses understanding of system structures and underlying mental models to identify and clearly explain possible leverage actions.</td>
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Example of a cause of endangerment

Variation:
Cheetahs don't have a lot of variation in their genes. If one cheetah gets a disease it will spread extremely easy and they will die.

Example of a conservation effort

Cheetahs in captivity:
Most cheetahs are kept in captivity. When the cheetah is kept captive it can give birth easier and poachers and farmers can't shoot them. This affects both the birth and death fraction.

Original conservation idea

Encourage farmers to scare cheetahs away with donkeys or dogs instead of killing them. They can also trap them and give them to a preserve.
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Reporting Student Progress
Stock-Flow Map

Student achievement in 2010 and beyond