ENVISION 21

Deep Learning

SYSTEMS THINKING RUBRIC
GRADES K-2

CATALINA FOOTHILLS SCHOOL DISTRICT

TUCSON, ARIZONA

General Description and Suggestions for Use

The district's strategic plan, Envision21: Deep Learning, forms the basis for a focus on cross-disciplinary skills/proficiencies necessary for preparing our students well for a 21st century life that is increasingly complex and global. These skills, which are CFSD's "deep learning proficiencies" (DLPs) are represented as 5c + s = dlp. They are the 5Cs: (1) Citizenship, (2) Critical Thinking and Problem Solving, (3) Creativity and Innovation, (4) Communication, (5) Collaboration + S: Systems Thinking. CFSD developed a set of rubrics (K-2, 3-5, 6-8, and 9-12) for each DLP.

These rubrics were developed using a backward design process to define and prioritize the desired outcomes for each DLP. They provide a common vocabulary and illustrate a continuum of performance. By design, the rubrics were not written to align to any specific subject area; they are intended to be contextualized within the academic content areas based on the performance area(s) being taught and assessed. In practice, this will mean that not every performance area in each of the rubrics will be necessary in every lesson, unit, or assessment.

The CFSD rubric for **Systems Thinking** was designed as a cross-disciplinary tool to support educators in teaching and assessing the performance areas associated with this proficiency:

- **Change Over Time**
- **Interdependencies**
- **Consequences**
- **System as Cause**
- **Leverage Actions**
- **Big Picture**
- **Self-Regulation and Reflection**

This tool is to be used primarily for formative instructional and assessment purposes; it is not intended to generate psychometrically valid, high stakes assessment data typically associated with state and national testing. CFSD provides a variety of tools and templates to support the integration of **Systems Thinking** into units, lessons, and assessments. When designing units, teachers are encouraged to create authentic assessment opportunities in which students can demonstrate mastery of content and the deep learning proficiencies at the same time.

The approach to teaching the performance areas in each rubric may vary by subject area because the way in which they are applied may differ based on the field of study. Scientists, mathematicians, social scientists, engineers, artists, and musicians (for example), all collaborate, solve problems, and share their findings or work within their professional communities. However, the way in which they approach their work, the tools used for collaboration, and the format for communicating their findings may vary based on the profession. These discipline-specific expressions of the 5Cs + S may require some level of customization based on the subject area. Each rubric can also be used to provide students with an opportunity to self-assess the quality of their work in

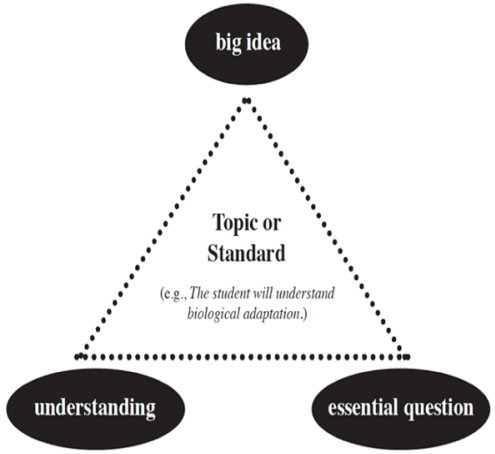
relation to the performance areas. Student-friendly language or "I can" statements can be used by students to monitor and self-assess their progress toward established goals for each performance area.

Transfer

CFSD educators prioritize understanding and transfer to ensure that learning extends beyond the school experience. This 2019 version of the DLP, **Systems Thinking**, includes long-term **transfer goals** that describe autonomous applications of student learning in college, career, and civic life. "Drill and direct instruction can develop discrete skills and facts into automaticity…but they cannot make us truly able. Understanding is about *transfer*, in other words. To be truly able requires the ability to transfer what we have learned to new and sometimes confusing settings. The ability to transfer our knowledge and skill effectively involves the capacity to take what we know and use it creatively, flexibly, fluently, in different settings or problems, on our own" (Wiggins and McTighe, 2011, p. 40).

Big Ideas

This 2018 version of the DLP, **Systems Thinking,** includes a set of Understandings and Essential Questions (UEQs) developed by an interdisciplinary team of K-12 teachers and administrators with guidance from Jay McTighe, author of *Understanding by Design*. These big ideas will guide teachers toward the thoughtful design of assessments, units, and lessons that will facilitate transfer of deep learning. "Because big ideas are the basis of unified and effective understanding, they provide a way to set curriculum and instructional priorities...they illuminate experience; they are the linchpin of transfer…" (Wiggins and McTighe, 2011, p.71). "Understandings are the specific insights, inferences, or conclusions about the big idea you want your students to leave with" (Wiggins and McTighe, 2011, p. 80). "Essential questions make our unit plans more likely to yield focused and thoughtful learning and learners" (McTighe, 2017; McTighe & Wiggins, 2013, p. 17). The figure on the right represents the interrelationship among big ideas, understandings, and essential questions.



The **DLP Understandings** are written for K-12 because they express lasting, transferable goals for student learning. Understandings are meant to be revisited over time and across contexts. The continuity of working toward the same goals will help students deepen their understanding from Kindergarten to 12th grade. Understandings are primarily planning tools, although teachers may choose to share them with their students, if appropriate. Communicating an Understanding does not give away "the answer," since simply stating an Understanding is not the same as truly grasping its meaning.

The **Essential Questions** are teaching and learning tools that help students unpack the Understandings. They support inquiry and engagement with deep learning and therefore may vary in complexity across grade levels.

Systems Thinking Transfer Goals and UEQs

Transfer Goals	
Students will be able to independently use their learning to. . . • Employ the habits of a systems thinker to better understand situations, make effective decisions, and plan for the future.	
Understandings	**Essential Questions**
Students will understand that. . .	**Students will keep considering. . .**
• A system is comprised of interrelated and interdependent parts which serve a specific purpose; changing one part of a system affects other parts.	• What is a system? • How do elements of a system affect each other? • How do the elements fit into the system as a whole? • Why are things the way they are? • What are the causal relationships within a system?
• Systems thinking enables us to look at problems and situations in new ways, which can lead to new solutions and insights.	• How can we use systems thinking to make predictions and solve problems?
• Systems thinkers use specific habits, tools, and vocabulary to represent, describe, and analyze systems and solve problems.	• What makes an effective systems thinker? • How can we use the habits of a systems thinker to help us understand and analyze a system? • How can we come to understand and improve a system? • Which tool(s) will be most effective in analyzing the relationships within the system?
• Systems thinkers observe and connect information in order to understand systems.	• What makes an effective systems thinker?
• A system's structure drives its behavior.	• Why are things the way they are?
• Examining a system from different perspectives helps us identify various mental models and better understand the system.	• How do mental models affect our thoughts and actions? • Why are things the way they are?

• Recognizing patterns of change enables prediction and guides planning for the future.	• What has changed and why? • How can looking at what *has* happened help us predict what *will* happen? • How can we use what we know and have learned to plan for the future? • How does understanding one system help us understand another system?
• Actions can have short-term, long-term, and/or unintended consequences; we can strategically choose leverage actions that produce or increase desired results.	• How do we know the effects of our actions? • How do we know which action or change will make the greatest difference? • How can even a small action or change make a difference?

Self-Regulation and Reflection Transfer Goals and UEQs

Transfer Goals	
Students will be able to independently use their learning to. . . • Improve performance and persevere through challenges by applying deliberate effort, appropriate strategies, and flexible thinking.	
Understandings	**Essential Questions**
Students will understand that. . .	**Students will keep considering. . .**
1. Effective learners set goals, regularly monitor their thinking, seek feedback, self-assess, and make needed adjustments.	• How am I doing? How do I know? What are my next steps? • What is the most effective way to monitor my progress? • How do I know which feedback will help me improve my work? • How can I get useful feedback? • How do I prioritize my work?
2. We can always improve our performance through deliberate effort and use of strategies.	• How can I keep getting better at systems thinking?

The deep learning proficiencies (5c+ s) are highly interconnected. For example, productive collaboration is contingent upon effective communication. Efficient and effective problem solving often requires collaboration skills. Divergent and convergent thinking, which are traits of Creativity and Innovation, are directly related to critical thinking. Our students will need to use a combination of proficiencies to solve problems in new contexts beyond the classroom. Therefore, it is important to be clear about which proficiency and/or performance area(s) are the focus for student learning, and then to assist students in understanding the connections between them and how they are mutually supportive.

What does Score 1.0 – Score 4.0 mean in the rubrics?

The rubrics are intended to support student progress toward mastering the deep learning proficiencies (DLPs). Four levels of performance are articulated in each rubric: Score 1.0 (Novice), Score 2.0 (Basic), Score 3.0 (Proficient), and Score 4.0 (Advanced). The descriptions follow a growth model to support students in developing their skills in each performance area. Scores 1.0 (Novice) and 2.0 (Basic) describe positive steps that students might take toward achieving Score 3.0 (Proficient) or Score 4.0 (Advanced) performance.

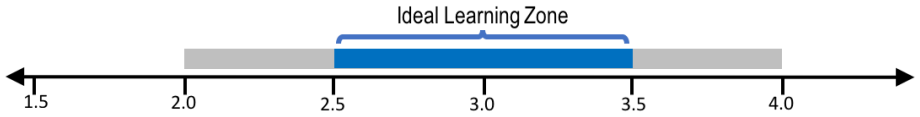
When using the rubrics to plan for instruction and assessment, teachers need to consider the knowledge and skills described in the Score 2.0 column (Basic) to be embedded in the Score 3.0 (Proficient) and 4.0 (Advanced) performance. The Novice level (Score 1.0) indicates that the student does not yet demonstrate the basic skills within the performance area, but that he/she exhibits related readiness skills that are a stepping-stone to a higher level of proficiency. Descriptions at the Novice level also include likely misconceptions that the student might exhibit.

The descriptive rubrics are designed to illustrate students' depth of knowledge/skill at various levels in order to facilitate the instructional and assessment process for all learners. At some performance levels, the indicators may remain the same, but the material under study is more or less complex depending on the grade level band (for example: the complexity of the material at grades 6-8 differs from that of grades 3-5 or 9-12).

The following descriptions explain the four levels on the rubric:

- Score 1.0 (Novice): Describes student performance that demonstrates readiness skills and/or misconceptions and requires significant support.
- Score 2.0 (Basic): Describes student performance that is below proficient, but that demonstrates mastery of basic skills/knowledge, such as terms and details, definitions, basic inferences, and processes.
- Score 3.0 (Proficient): Describes student performance that is proficient – the targeted expectations for each performance area of the DLP.
- Score 4.0 (Advanced): Describes an exemplary performance that exceeds proficiency.

The image below represents the ideal learning zone for students as 2.5 – 3.5.



Glossary

Long-term consequences: Intended or unintended consequences that have longer lasting effects and that are harder to anticipate.

Short-term consequences: Short-term or immediate effects that are often easier to identify or predict. Many humans make decisions just based on short-term consequences.

*Transfer: Before a student can successfully transfer, he/she must first master the other skills within each performance area.

With adult support/guidance: In this rubric, working with adult support or guidance refers to a teacher walking an individual student through the process step-by-step. "With adult support" does not include whole class scaffolding strategies such as graphic organizers, turn and talk, etc.

Sources

The following sources directly influenced the revision of CFSD's rubrics:

- Catalina Foothills School District. (2011, 2014, 2016, 2018). Rubrics for 21st century skills and rubrics for deep learning proficiencies. Tucson, Arizona.
- Waters Center for Systems Thinking, https://waterscenterst.org/

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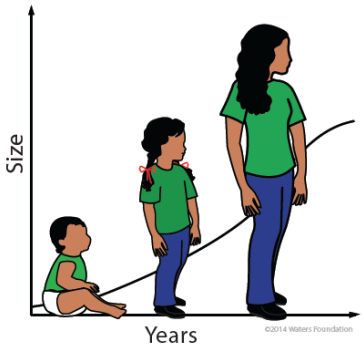
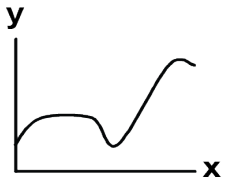
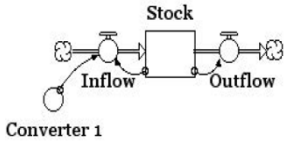
A **system** is a collection of elements that interact with each other over time to function as a whole (Waters Center for Systems Thinking, 2018). A **systems thinker** is anyone who uses the **Habits of a Systems Thinker** (see end of document) in combination with the concepts and visual tools of systems thinking to increase understanding of systems and how they influence both short- and long-term consequences. Many systems thinking concepts are embedded either explicitly or implicitly within the Habits of a Systems Thinker. The CFSD Systems Thinking rubrics include the concepts of Change Over Time, Interdependencies, Consequences, System-as-Cause, Leverage Actions, and Big Picture. Systems thinking provides students with a more effective way to interpret the complexities of the world in which they live—a world that is increasingly dynamic, global, and complex.

Change Over Time, page 8 	**Consequences, page 10** 	**Leverage Actions, page 12** 
Interdependencies, page 9 	**System-as-Cause, page 11** 	**Big Picture, page 13** 

SYSTEMS THINKING

DLP Performance Area	1.0 (Novice) The student may exhibit the following readiness skills for Score 2.0:	2.0 (Basic) When presented with a grade-appropriate task, the student:	3.0 (Proficient) In addition to Score 2.0, the student:	4.0 (Advanced) In addition to Score 3.0, the student may:
CHANGE OVER TIME  **Behavior-over-time graphs**  **Stock-flow maps**	**Identification and Explanation:** Identifies examples of key terms such as *change*, *variable*, *before, after*, and/or *over time* from provided examples and definitions. **Representation:** Retells a sequence of events by ordering a provided set of pictures *(for example: orders pictures showing the lifecycle of a chicken).* **Transfer*:** Uses change over time vocabulary *(for example: similar, change, and/or over time)* to describe an everyday situation or an experience in their life *(for example: book, social dynamic, sports, etc.).* See possible student misconceptions following the rubric.	**Identification and Explanation:** Describes an immediate or short-term change that occurs *(for example: it was sunny when we went to recess, but then the sky got darker when the weather changed to rain").* Describes a change as a series of events that connect over time *(for example: My friend and I were mad at each other yesterday. Then we spent time apart from each other today, and now we are not mad at each other).* **Representation:** Explains the "story" of a trend line on a provided behavior-over-time graph *(for example: uses a provided graph to explain how a character's emotion changed over the course of a book, or uses a provided graph to explain how the amount of money in a bank account changes over time).* **Transfer*:** Identifies common elements of two situations involving change over time.	**Identification and Explanation:** Describes a change that occurs over time. Lists and orders events. Identifies elements of a system that change over time *(for example: the amount of precipitation in an ecosystem or how a character's courage changes across a story).* **Representation:** Plots a change over time, given a graph with pre-defined *x* and *y* axes *(for example: plots a trend line showing how a student's energy level changes throughout the school day, justifying why energy levels increase and decrease).* **Transfer*:** Generalizes the key elements of situations that change over time *(for example: "Change over time in both of these stories is the character changing her feelings about a friend or friendship.").*	**Identification and Explanation:** Describe general trends in change over time related to one another *(for example: the growth of plants correlates with the increase in water and light).* Explain why elements of a system change over time *(for example: create a stock-flow map showing the causes of an animal population's growth/decline over time).* **Representation:** Construct a behavior-over-time graph to plot a general change over time, including defining a time frame (x axis) and a scale for changes in an accumulation (*y* axis) *(for example: From "There's a Bird on my Head," by Mo Willems – constructs a graph that shows how Gerald's anxiety increases slowly over the first half of the book, very quickly when the birds have babies, and rapidly decreases once the birds leave his*

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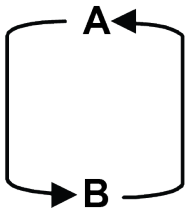
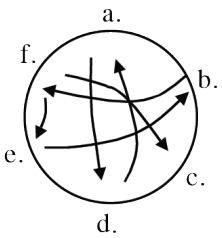
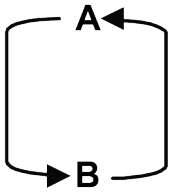
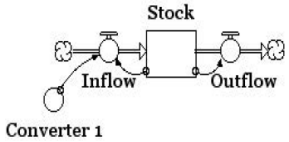
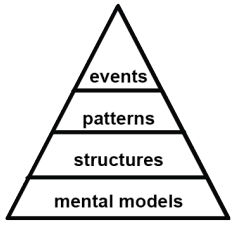
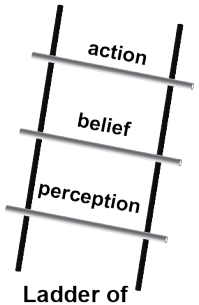
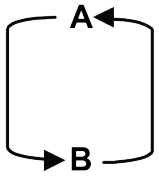
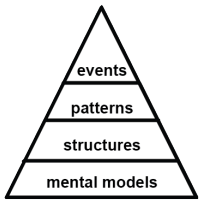
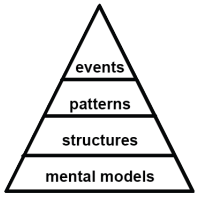
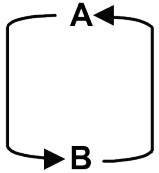
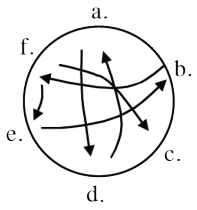
				head. Explains this graph through writing or speech.). **Transfer*:** Apply conclusions about change over time in one situation to a situation of a similar type (*for example: how a baby chick grows over time to how a puppy grows over time).*
INTERDEPENDENCIES  **Causal loops**  **Connection circles**	**Identification and Explanation:** Identifies examples of key terms such as *cause*, *effect*, *interdependent*, and/or *relationship* when provided with definitions and examples. **Representation:** Labels events on a provided systems tool to distinguish events that are causes and effects *(for example: draws an arrow on a connection circle at the cause and leading to the effect).* **Transfer*:** Identifies key concepts such as *cause and effect*, *dependent*, and/or *interdependent* when provided definitions and examples. See possible student misconceptions following the rubric.	**Identification and Explanation:** Identifies simple cause and effect situations in provided examples *(for example: smoke causes a fire alarm to go off; practicing reading causes increased stamina for reading to self; cutting down trees in the rainforest leads to habitat loss).* **Representation:** Represents key elements in a system *(for example: draws and/or labels different parts of a plant).* **Transfer*:** Identifies common elements of cause/effect relationships.	**Identification and Explanation:** Identifies and explains a single cause-and-effect loop in a single system *(for example: increasing bee populations [pollinators] lead to higher plant populations that leads to increasing food for the bees which supports bee populations*). Uses key terms including *cause*, *effect*, *interdependent*, and/or *connection* to describe an interdependent relationship. **Representation:** Represents connections between key elements of a system (*for example: uses a connection circle to show the relationships between: hunger, thirst, eating, drinking, energy, and physical activity).* **Transfer*:** Generalizes the key elements of a system with interdependent relationships	**Identification and Explanation:** Distinguish whether a loop represents a reinforcing or balancing process (*for example: as predator numbers increase, prey population decreases, which leads to decreased predator numbers, which is a balancing loop. Or, as a student eats healthy foods, they have more energy to play, and they add more healthy foods to their diet, which is a reinforcing loop).* **Representation:** Represent a circular causal relationship between two elements of a system (*for example: uses a causal loop to show the reinforcing feedback between kindness and acts of kindness).* **Transfer*:** Compare interdependencies in one situation to a situation of a similar type (*for example: the number of predators such as*

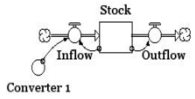
			and provides relevant examples (*for example: "These kinds of systems have two or more parts that need each other to be successful," so plants and animals in the desert ecosystem would be an example because . . .).*	*mountain lion populations related to the number of prey such as deer population in an ecosystem parallels the number of a plant population to the number of a pollinating species such as bees*).
CONSEQUENCES  **Causal loops**  **Stock-flow maps and computer models**	**Identification and Explanation:** Identifies examples of *short-term consequences* and *long-term consequences, intended consequences*, and *unintended consequences* from provided events. **Representation:** Lists results occurring from actions. **Transfer*:** Explains key terms needed for transfer such as *action*, *consequences*, *short-term*, *long-term*, *intended* and/or *unintended* when provided with examples or definitions. See possible student misconceptions following the rubric.	**Identification and Explanation:** Explains a consequence for a specific action *(for example: Mercy Watson climbed into bed when she was scared, so the bed broke.).* **Representation:** Connects results or consequences occurring from actions on a provided causal loop diagram. **Transfer*:** Identifies and compares the characteristics of short- and long-term consequences *(see characteristics of short- and long-term consequences below; for example: In music class, a student acted out because he/she was only thinking about getting others to laugh and was not thinking about how his/her action would interrupt learning – people often forget to think about long-term consequences).*	**Identification and Explanation:** Explains the difference between a short-term consequence and long-term consequence, and provides a relevant example from a given text or a personal experience *(for example: I cut in line so I got to use the swings first, but then I had to write an apology to the student I cut in line.).* **Representation:** Identifies short-term and/or long-term consequences of a particular action on a provided causal loop diagram. **Transfer*:** Generalizes the key elements of a situation involving actions and consequences (*for example: "This situation involves an individual who breaks rules" or "In this situation, a solution fixes the problem, but creates others in other areas"*).	**Identification and Explanation:** Identify and explain short-term and long-term intended consequences of a particular action (*for example: explains how reducing water use at home will result in short-term economic benefit to the homeowner, and long-term benefit to the desert ecosystem).* **Representation:** Represent short- and long-term intended consequences through a causal loop diagram, stock-flow map, computer model/simulation, and/or kinesthetic activity. **Transfer*:** Apply conclusions about the consequences in one situation to a situation of a similar type (*for example: consequences of the actions of one character to the actions of a character in a different text).*

			Compares common elements of actions and consequences in two situations using a provided comparison graphic organizer.	
SYSTEM AS CAUSE  Iceberg  Ladder of inference	**Identification and Explanation:** Identifies examples of different systems *(for example: a plant system, an ecosystem, a gear system*). Chooses examples of *observable events and patterns of behavior* from provided samples or lists. **Representation:** Labels system components on a systems tool *(for example: iceberg or a ladder of inference)* using provided terms. **Transfer*:** Defines key vocabulary necessary to transfer concepts such as observable events, patterns of behavior, structures, mental models, similar and/or different. See possible student misconceptions following the rubric.	**Identification and Explanation:** Identifies elements of a familiar system (*for example: in a classroom system, the students, the teacher, the lesson activities, the work, and the assessments would be elements of a classroom system*). **Representation:** Classifies examples of system components such as observable events, patterns of behavior, structures, and/or mental models of a provided, familiar representation of a system. **Transfer*:** Identifies common elements of a system.	**Identification and Explanation:** Identifies a system's observable events and possible patterns of behavior using a systems tool, such as the iceberg (*for example: observation of students using active listening during discussions; possible pattern of behavior might be using signals to indicate a wish to share, or using a talking stick during discussions, etc.).* **Representation:** Visually represents observable events and patterns of behavior of a familiar system on a systems tool. **Transfer*:** Identifies two systems with similarities at the level of observable events, patterns of behavior, structures of the system, or mental models.	**Identification and Explanation:** Identify a system's structures and mental models that result in observable patterns and events. **Representation:** Visually represent system structures and mental models of a familiar system on a systems tool. **Transfer*:** Compare two systems at all the levels of observable events, patterns of behavior, structures of the system, and mental models (*for example: compare a classroom and a city or town*).

LEVERAGE ACTIONS				
 Causal loops  Iceberg	**Identification and Explanation:** Identifies desirable and undesirable effects of an action. **Representation:** Illustrates a desirable outcome and an undesirable outcome (using pictures, written words, verbal report, artistic representation) or chooses pictures that depict desirable and undesirable outcomes. **Transfer*:** Defines and provides examples of key vocabulary about basic leverage concepts such as *desirable*, *undesirable*, *leverage*, and/or *similar*. See possible student misconceptions following the rubric.	**Identification and Explanation:** Describes the basic concept of leverage action (*i.e., an action that would bring about a desirable effect).* **Representation:** Labels events as a "cause" or an "effect" using a provided systems tool *(for example: draws arrows on a connection circle from cause to effect).* **Transfer*:** Identifies one or more common attributes of leverage or leverage actions *(for example: an action that has a desirable effect, an action that has the potential to change how a system functions, etc.).*	**Identification and Explanation:** Identifies potential leverage actions within a specific situation (*for example: different ways a student could make a positive impact on their school environment*). **Representation:** Depicts cause and effect relationships within a system using systems diagrams *(for example: stock-flow map, causal loop).* **Transfer*:** Generalizes the key elements of a situation with multiple possible leverage actions (*for example: "This situation offers several ways a person could help our classroom.").*	**Identification and Explanation:** Identify and explain a more high-leverage action that made a change within a system *(for example: when farmers in Arizona changed how they planted, the soil system was improved).* Rank potential leverage actions within a system using the criteria of desirable effectiveness *(for example: criteria for ranking leverage actions might include time it would take to implement, number of unintended consequences that might result, long-term efficacy of action, etc.).* **Representation:** Represent potential high-leverage actions within a system (*for example: all the places humans could intervene in the water cycle, through a causal loop diagram, stock-flow map, system dynamics computer model, or iceberg).* **Transfer*:** Compare leverage action(s) in two similar systems (*for example: compare the leverage actions of one character in a story to the leverage actions of another character in a different story*; the boy *in The Curious Garden makes his community*

 Reviewed by Waters Center for Systems Thinking Associates

				better through service and leading by example. The cows in Click, Clack, Moo make their community better through letter writing and protests. Or similarly, comparing the tactics of Cesar Chavez and Martin Luther King, Jr.
BIG PICTURE  Iceberg  Causal loops  Connection circles	**Identification and Explanation:** Identifies parts of a system from provided information (*for example: matches names of parts of plants to a diagram of a plant*). **Representation:** Selects pictures or drawings to represent a sequence of events. Selects labels or written descriptions for diagrams. **Transfer*:** Defines key vocabulary about basic system concepts such as *system*, *attributes*, *cycle*, *sequence*, and/or *connected*. See possible student misconceptions following the rubric.	**Identification and Explanation:** Explains sequential events or parts of a system in isolation from other events/parts of the system (*for example: explains the function of the roots of a plant without connecting that function to the other parts of the plant*). **Representation:** Lists goals, problems, and/or behaviors of the actors/parts of a system on a provided organizer. **Transfer*:** Identifies one or more common attributes of how a system operates *(for example: a system can appear organized and a system can also appear chaotic. A system can be operated by one person, a group of people, or no one).*	**Identification and Explanation:** Identifies multiple parts of a system and explains the basic details or functions of the parts as they work together (*for example: explains how each part of a plant serves a specific function and connects all parts as needed for the plant's survival*). **Representation:** Creates a representation of the parts of a system and shows connections among the parts using a systems tool (*for example: the predators of the desert and the prey of the desert in a simple connection circle).* **Transfer*:** Generalizes the key elements of how a system operates (*for example: "This lunchroom is out of control because it is too crowded or there are no rules"; Classrooms function better when everyone has the*	**Identification and Explanation:** Identify and explain behaviors, goals, problems, and/or relationships among parts within a system as a series of interrelated details or events. (*for example: how a plant's success and survival is related to its physical environment).* **Representation:** Create a representation of a whole-system perspective using a systems tool (*for example: how coyotes, rabbit and plant populations relate to one another using a stock-flow map).* **Transfer*:** Apply conclusions about how one system operates to a system of a similar type (*for example: an orchestra conductor with the orchestra and the music teacher during a school chorus performance).*

 **Stock-flow maps and computer models**			*same mental models about learning).* Identifies common elements of a system in two situations.	
SELF-REGULATION AND REFLECTION	**Reflection:** Identifies own strengths and weaknesses as a systems thinker with adult support. **Planning:** Sets personal goals for applying systems thinking habits and tools with adult support. **Mindset:** Explains the relationship between effort and success *(for example: "The harder I work at this, the better I'll be at it"; "I will work harder in this class from now on.").* See possible student misconceptions following the rubric.	**Reflection:** Identifies own strengths and weaknesses as a systems thinker. **Planning:** Sets personal goals for applying systems thinking habits and tools. **Mindset:** Demonstrates a desire to improve *(for example: employs more practice, sets goals for improvement, asks for help from others instead of giving up).*	**Reflection:** Assesses application of the habits and tools of a systems thinker in response to feedback and/or the rubric. Describes the learning that resulted from systems thinking. **Planning:** Sets goals for applying systems thinking based on feedback and/or the rubric. **Mindset:** Demonstrates a growth mindset (the belief that he or she can get "smarter" at systems thinking through effective effort) in response to setbacks and challenges *(for example: persists on difficult tasks, takes risks in the learning process, accepts and uses feedback/criticism, is comfortable making mistakes, explains failure from a growth mindset perspective).*	**Reflection:** Accurately reflect on the application of systems thinking habits and tools; use reflection and/or feedback to revise thinking or to improve ideas. Question and critique own thinking process. **Planning:** Seek out, select, and use resources and strategies to achieve goals for improving the application of systems thinking habits and tools. **Mindset:** Proactively improve own areas of weakness by employing effective strategies to increase growth mindset *(for example: perseverance, taking risks, effective decision-making, actively seeking others' feedback, deliberate practice, finding and using external resources [skilled peers, other adult experts] to enrich and extend learning).*

Possible Misconceptions: K-2 Systems Thinking

The following chart lists possible misconceptions about **Systems Thinking**. Understanding student misconceptions can help teachers develop lessons that proactively address these barriers to deep learning and transfer.

Students might exhibit the following misconception, belief, or perception that…		
Change Over Time	**Identification and Explanation**	• All change happens in the same way. • Once change is initiated, it will follow the same rate or trend over time. • Any action will result in immediate change.
	Representation	• Change-over-time graphs all take the same shape. • Actions (verbs) and things (nouns) are interchangeable as stocks and flows. • Reinforcing and balancing loops are value judgments (for example: reinforcing = good and balancing = bad).
	Transfer	• All situations are unique; therefore, analysis of one cannot be applied to the analysis of another. • A generalization alone is a sufficient basis for transfer.
Interdependencies	**Identification and Explanation**	• Two things are related because they happen at the same time. • Correlation equals causation.
	Representation	• Systems thinking tools are interchangeable in all situations.
	Transfer	• All situations are unique; therefore, analysis of one cannot be applied to the analysis of another. • A generalization alone is a sufficient basis for transfer.

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Consequences	**Identification and Explanation**	• There are only intended consequences. • One type of consequence (short- or long-term, intended or unintended) is more important than another.
	Representation	• Systems thinking tools are interchangeable in all situations.
	Transfer	• All situations are unique; therefore, analysis of one cannot be applied to the analysis of another. • A generalization alone is a sufficient basis for transfer.
System as Cause	**Identification and Explanation**	• My perception of a situation is accurate. • Events just "happen" for no reason or are caused by external factors. • My perspective, beliefs, and/or actions do not influence the system, situation, or behavior of others. • Implementing a structure or strategy once should lead to a change in events. • Once the patterns and/or observable events change, the structures are no longer needed to maintain the outcome.
	Representation	• All information about the system is of equal value. • We can fully understand a system by analyzing isolated parts. • Complicated or lengthy explanations or representations are inherently better.
	Transfer	• All situations are unique; therefore, analysis of one cannot be applied to the analysis of another. • A generalization alone is a sufficient basis for transfer.

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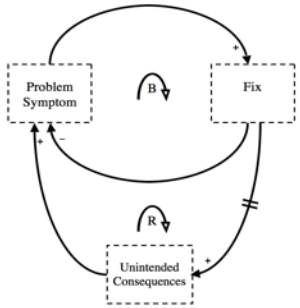
Leverage Actions	**Identification and Explanation**	• All leverage actions are equally impactful. • Any action is a leverage point because it is part of the system. • A leverage point must be large and obvious. • A leverage action must come from an external source.
	Representation	• Systems thinking tools are interchangeable in all situations.
	Transfer	• All situations are unique; therefore, analysis of one cannot be applied to the analysis of another. • A generalization alone is a sufficient basis for transfer.
Big Picture	**Identification and Explanation**	• We cannot begin to explore the big picture until we fully understand all the details. • The details don't matter in relation to the big picture. • A system only has one perspective, or only one perspective that matters. • Big-picture understanding is static; once we identify it, it never changes.
	Representation	• All elements of the system are of equal importance. • Systems thinking tools are interchangeable in all situations.
	Transfer	• All situations are unique; therefore, analysis of one cannot be applied to the analysis of another. • A generalization alone is a sufficient basis for transfer.

Possible Misconceptions: K-2 Self-Regulation and Reflection

The following chart lists possible misconceptions about **Self-Regulation and Reflection.** Understanding student misconceptions can help teachers develop lessons that proactively address these barriers to deep learning and transfer.

Students might exhibit the following misconception, belief, or perception that…		
Self-Regulation and Reflection	**Reflection**	• Reflection is all about what I think; other people's perspectives don't matter. • Only the teacher's perspective matters when it comes to identifying strengths and weaknesses. • I don't have any weaknesses. • I don't have any strengths. • All weaknesses affect my performance in the same way. • Reflection is a waste of time; I don't need to reflect to improve.
	Planning	• A goal is the same thing as a plan. • Any goal is a worthy goal. • Short-term goals aren't important. • I don't need a plan; if I set a goal, I will achieve it. • I should set goals in areas where I am already successful. • I should set the same goal over and over. • Someone else will give me resources and ideas about how to improve.
	Mindset	• Systems thinking is a talent and not a skill; I am as good at it as I'll ever be. • If I'm really good at something, I won't encounter any challenges. • If I experience a setback, I've failed. • Others' feedback can't help me. • Mistakes are bad; smart people don't make mistakes. • The safe route leads to guaranteed success.

Archetype: A multi-loop causal loop diagram that represents behavior commonly seen in complex systems. The archetypes are named - for example, "Fixes That Fail." In these systems, a problem is solved by some fix (a specific solution) that causes an immediate positive effect. Nonetheless, the "side effects" of this solution, after a time delay, make the problem worse.



Feedback: The interaction between two stocks that affect each other in turn.

- Balancing Feedback: "Effect of an action returned (fed back) to oppose the very action that caused it. Balancing feedback has a correcting or stabilizing effect on the system, and it reduces the difference (variance) between where the system is (the current status) and where it should be (the target value, or objective). For example, demand and supply in an economy work on each other to reach a stable (equilibrium) state through the feedback of information about price and availability. If supply is known to be greater than demand, price falls. Low price forces suppliers to pull out of the market, causing shortage that results in increase in price. High price attracts more supplies than there is demand ... and so on until a rough parity is achieved. Criticism can also be a balancing feedback if it results in the desired change in the recipient's behavior." (BusinessDictionary.com)

- Reinforcing Feedback: "Effect of an action, change, or decision returned to amplify or bolster what caused it. Reinforcing feedback drives a system increasingly faster in the direction it is already going whether away from its goal (called a vicious circle) or towards it (called a virtuous circle). It may destroy the system by pushing it beyond its limits unless the circle runs out of steam or is countered by a balancing feedback. A small ball of snow rolling downhill is an example of vicious circle. As its size continues to grow, it picks up ever-increasing amounts of snow. This process stops only when the giant ball of snow disintegrates under its own weight or runs out of slopes to roll down. Compound interest is an example of a virtuous circle. A praise or a reward can also be a reinforcing feedback if it results in the desired change in the recipient's behavior." (BusinessDictionary.com)

Flow: Rate of increase or decrease of a quantity that accumulates in a stock.

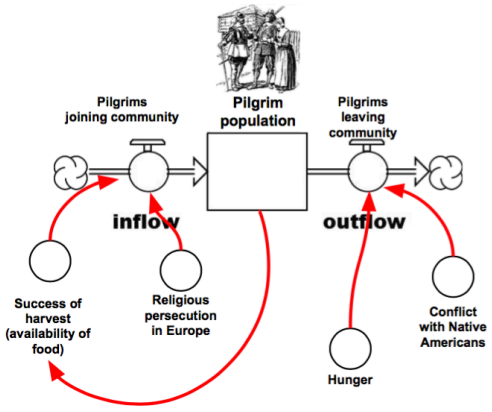
Limits: A definition of the boundaries and extent of the system, including which physical, environmental, structural, or temporal elements are relevant, and which aren't; systems may be nested within one another. Defining the limits of a system is a crucial part of the analysis of the system.

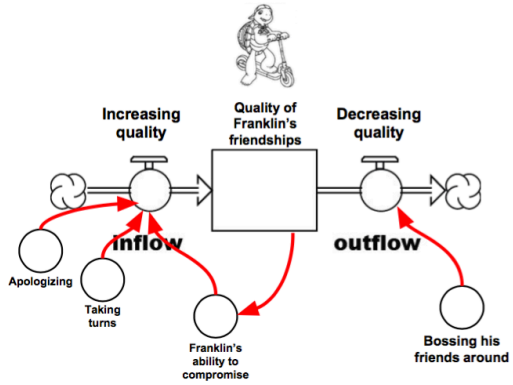
Stock: (Accumulation): A quantity that can be built up or depleted over time.

Time Delay: A gap in time between a cause and its effect within a system. Time delays may make systems hard to understand or predict.

Curricular Examples for Interdependencies: The following examples from grades K-2 may give teachers an idea of how to use stock-flow maps:

Subject Area	Stock	Flow	Converters	Potential Feedback Relationships
Science	Number of trees (Natural Resources)	• Increasing • Decreasing	• Planting new trees (increasing) • Cutting down to build houses (decreasing)	Planting trees specifically for housing instead of taking from nature (balancing feedback)
English Language Arts	Quality of Franklin's friendships (from *Franklin is Bossy*)	• Increasing • Decreasing	• Apologizing and taking turns (increasing) • Bossing his friends (decreasing)	Franklin's ability to compromise (reinforcing feedback)
Social Studies	Amount of money in a business' bank account (Economics)	• Increasing • Decreasing	• Sales of product (increasing) • Expenses (decreasing)	Increasing or decreasing the price based on the demand of the product (balancing feedback)
History	Pilgrim population	• Increasing • Decreasing	• People joining Pilgrim community and availability of food (increasing) • People leaving for new areas; hunger, and conflict with Native Americans (decreasing)	Success in planting their own food, building shelter (reinforcing feedback)



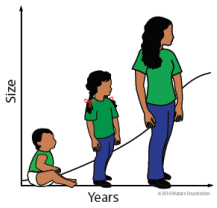


Curricular Examples for System as Cause:

Subject Area	System	Events	Patterns	Structures	Mental Models
Science	Chick population	Chicks hatch	• Embryo development over time • Heat over time	• Chick population stock-flow map • Loop showing how the incubator maintains the correct temperature	• All chickens should survive (Kinder) • Male chicks should be killed (Farmers)
Social Studies (Building Classroom Community)	Classroom Good Behavior Points	Students earn class points	• Points earned each day over time • Points earned each year	• Stock-flow map with points earned (no outflow) • Reinforcing loop showing how earning points increases good behavior and good behavior increases earning points.	• Students earn points because they want rewards • When students earn points, they are more likely to reflect on their behavior and are able to track trends in behavior.

Seeks to understand the big picture

Observes how elements within systems change over time, generating patterns and trends

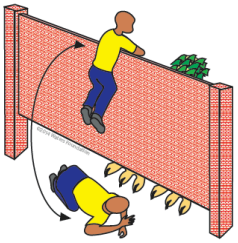


Recognizes that a system's structure generates its behavior

Identifies the circular nature of complex cause and effect relationships

Makes meaningful connections within and between systems

Changes perspectives to increase understanding



Surfaces and tests assumptions

Habits of a Systems Thinker

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 short-term, long-term and unintended consequences of actions

Pays attention to accumulations and their rates of change

Recognizes the impact of time delays when exploring cause and effect relationships

Checks results and changes actions if needed: "successive approximation"