ENVISION 21

Deep Learning

SYSTEMS THINKING RUBRIC

GRADES 3-5

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.

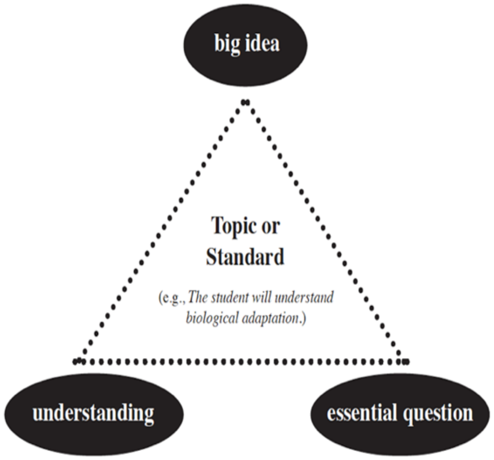
The approach to teaching the performance areas in each rubric may vary by subject area because the way in which they are applied may differ based on the field of study. Scientists, mathematicians, social scientists, engineers, artists, and musicians (for example), all collaborate, solve problems, and 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 2019 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 for teachers, 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 effect change, make predictions, and/or solve problems? • How can we maintain balance between the "big picture" and important details?
• 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? • What are the causal relationships within a system? • How can we maintain balance between the "big picture" and important details?
• A system's structure drives its behavior.	• How do structures drive 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 analyzing patterns help us predict or plan for the future? • What patterns or trends have emerged over time? • How does understanding of one system transfer to understanding of 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.	• What are the causal relationships within a system? • What are the systemic effects of actions in a system? • How does determining possible short-term, long-term, and/or unintended consequences help us make decisions? • How do we determine where a small change might have a long-lasting, desired effect?

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.

<u>What does Score 1.0 – Score 4.0 mean in the rubrics?</u>
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.

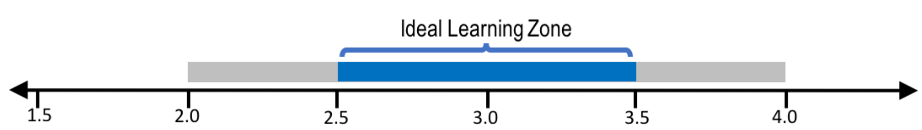
When using the rubrics to plan for instruction and assessment, teachers need to consider the knowledge and skills described in the Score 2.0 column (Basic) to be embedded in the Score 3.0 (Proficient) and 4.0 (Advanced) performance. The Novice level (Score 1.0) indicates that the student does not yet 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.

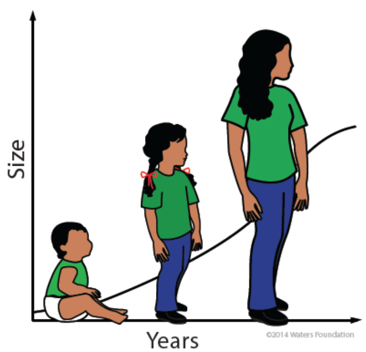
Sources

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/

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

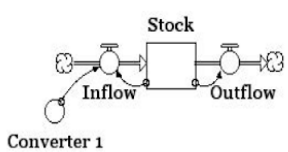
Leverage Actions, page 12

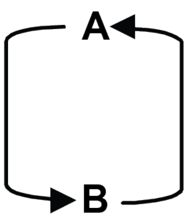
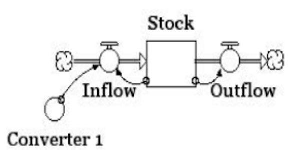
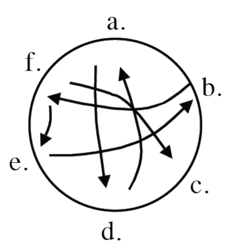
Interdependencies, page 9

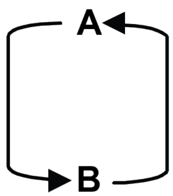
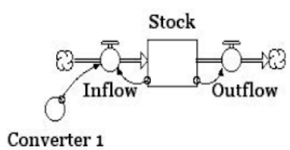
System-as-Cause, page 11

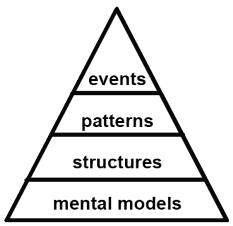
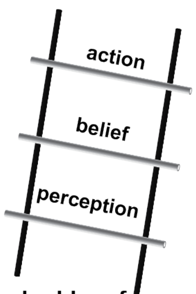
Big Picture, page 12

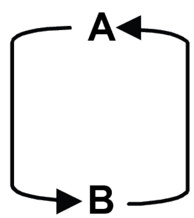
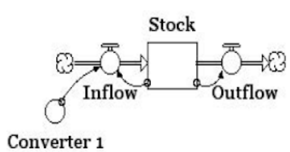
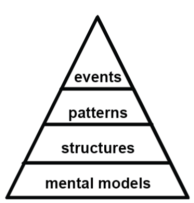
SYSTEMS THINKING

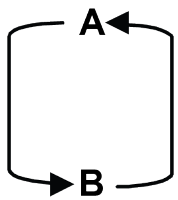
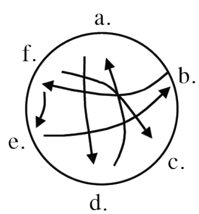
DLP Performance Area	1.0 (Novice) The student may exhibit the following readiness skills for Score 2.0:	2.0 (Basic) When presented with a grade-appropriate task, the student:	3.0 (Proficient) In addition to Score 2.0, the student:	4.0 (Advanced) In addition to Score 3.0, the student may:
CHANGE OVER TIME  **Behavior-over-time graphs**  **Stock-flow maps**	**Identification and Explanation:** Identifies key terms such as "rate of change," "element," "trend," and "pattern" when provided with examples or definitions. **Representation:** Labels events on a provided behavior-over-time graph. **Transfer*:** Identifies common elements of two situations involving change over time. See possible student misconceptions following the rubric.	**Identification and Explanation:** Describes a change that occurs over time. Lists and orders events. **Representation:** Charts a change over time, given a graph with pre-defined *x* and *y* axes. **Transfer*:** Generalizes the key elements of situations that change over time (*for example: "This situation involves an individual whose actions are influenced by her environment" or "I can see a steady increase followed by a sudden drop"*).	**Identification and Explanation:** Describes general trends in change over time *(for example: the increased support for American Independence correlates with the increase in Britain's repressive trade laws).* Identifies elements of a system that change over time. **Representation:** Constructs a behavior-over-time graph, annotated with evidence to support claims, to chart a general change over time, including defining a time frame (x axis) and a scale for changes in an accumulation (*y* axis) (*for example: line graph showing a general trend*). **Transfer*:** Applies conclusions about change over time in one situation to a situation of a similar type (*for example: perseverance over time for two characters in different texts*).	**Identification and Explanation:** Describe the nature of specific trends in changes over time (*for example: a gradual decrease of Native Americans in the American West, or the uneven increase in the number of wolves in Arizona).* Analyze why elements of a system change over time. **Representation:** Construct a detailed behavior-over-time graph (*for example: depicts transitions, annotates with evidence supporting claims, etc.*) to chart specific changes over time (including specific changes in rate, relationship between general trend and transition points). **Transfer*:** Apply understanding of an identified change over time to analyze a situation of a different type that operates in a similar manner (*for example: a fictional character's perseverance over time compared to that of an historical figure*).

INTERDEPENDENCIES  **Causal loops**  **Stock-flow maps**  **Connection circles**	**Identification and Explanation:** Identifies key terms including “feedback loop,” “reinforcing,” “balancing,” “cause,” and “effect” in provided examples. Identifies simple cause and effect situations in provided examples. **Representation:** Represents key elements in a system *(for example: draws and/or labels different parts of a plant).* Explains a given systems tool using systems terminology. **Transfer*:** Identifies common elements of cause/effect relationships in similar events or situations. See possible student misconceptions following the rubric.	**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*). **Representation:** Represents connections between key elements of a system (*for example: uses a connection circle to demonstrate as Despereaux’s courage increases, his fear decreases).* **Transfer*:** Generalizes the key elements of a system with interdependent relationships (*for example: “This system has two groups that depend on each other” or “This system involves interdependent parts”).*	**Identification and Explanation:** Distinguishes 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 process, or as a muscle pair contracts, it pulls on bones and joints to create a specific movement in a desired direction, which is a reinforcing process because the dynamic would be sustaining*). **Representation:** Represents a circular causal relationship between two elements of a system (*for example: uses a stock-flow map or causal loop diagram*). **Transfer*:** Compares interdependencies in one situation to a situation of a similar type (*for example: the increase in a predator population, such as mountain lions, in response to an increase in a prey population, such as deer, in an ecosystem parallels the increase in a plant population in response to an increase in a pollinating species such as bats*).	**Identification and Explanation:** Identify and explain causality in a system of multiple connected loops. Explain the behavior over time of any variable, or stock in the system in relation to another variable or stock *(for example: hawk, songbird, and insect populations are linked in two connected loops. See below).* **Representation:** Represent causality in a system of multiple connected loops (*for example: uses a stock-flow map or causal loop diagram*). Identify when causality can best be represented with a stock-flow map or causal loop diagram (*for example, the interdependence between Arizona population growth and amount of available natural resources can best be represented with a stock-flow map).* **Transfer*:** Apply conclusions about key interdependencies in one situation to a situation of another type (*for example: the interdependent functions of a factory or manufacturing plant are similar to the interdependent parts of a cell).*

CONSEQUENCES  **Causal loops**  **Stock-flow maps and computer models**	**Identification and Explanation:** Explains a consequence for an action. Classifies examples of "short-term consequences" and "long-term consequences," "intended consequences," and "unintended consequences" from provided events. **Representation:** Lists results occurring from actions. **Transfer*:** Identifies and compares the characteristics of short- and long-term consequences. See possible student misconceptions following the rubric.	**Identification and Explanation:** Explains the difference between a short-term consequence and long-term consequence. Explains the difference between intended and unintended consequences. **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"*). Compares common characteristics of actions and consequences in two situations using a provided comparison graphic organizer.	**Identification and Explanation:** Identifies and explains 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:** Represents short- and long-term intended consequences through a causal loop diagram, stock-flow map, computer model/simulation, and/or kinesthetic activity. **Transfer*:** Applies conclusions about the consequences in one situation to a situation of a similar type (*for example: consequences of the actions of early Plymouth Pilgrims to the actions of early Western settlers).*	**Identification and Explanation:** Identify and explain observed short- term and long-term unintended consequences as a result of an action or series of actions (*for example: explains a case in which "the most obvious solution" made a situation worse in the long term*). Predict and explain potential unintended consequences of an action (*for example: how a proposed solution could potentially backfire*). **Representation:** Show the short- and long-term intended and unintended consequences of actions within a complex system using a systems archetype (*for example: using a Fixes That Fail archetype to represent the slavery compromises prior to the Civil War).* **Transfer*:** Apply conclusions about consequences in one situation to a situation of another type (*for example: the effects of increasing the distance of the load from the fulcrum in a simple machine to the effects of carrying a heavy object on a joint such as the elbow).*

SYSTEM AS CAUSE  Iceberg  Ladder of inference	**Identification and Explanation:** Identifies elements of a system from provided examples (*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:** Labels elements of a system with provided systems tools *(for example: iceberg or a ladder of inference).* **Transfer*:** Identifies common elements of a system. See possible student misconceptions following the rubric.	**Identification and Explanation:** Identifies observable events and patterns of behavior in a familiar system (*for example: observations/events – students performing well on a test; pattern of behavior – homework completion and earlier test results*). **Representation:** Classifies given information as observable events, patterns of behavior, structures, and/or mental models of a provided system. **Transfer*:** Identifies two systems with similarities at the levels of observable events, patterns of behavior, structures of the system, and/or mental models.	**Identification and Explanation:** Identifies a system's structures and mental models using a systems tool, such as the iceberg (*for example: underlying structures - lesson design and peer tutoring; and mental model - "all students can be successful with deliberate practice and feedback"*). **Representation:** Visually represents observable events, patterns of behavior, structures of the system, and mental models. *[If using an iceberg: uses systems thinking tools on different levels of the iceberg to model the system (for example: behavior-over-time graphs [BOTGs] on the patterns level; stock-flow maps, causal loops, and archetypes on the structures level; ladder of inference on the mental models level.)]* **Transfer*:** Compares 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*).	**Identification and Explanation:** Explain how a system's underlying structures, mental models, and patterns of behavior result in observable events (*for example: we can attribute improved student performance to underlying structures such as lesson design and peer tutoring, which emerge from the mental model that "all students can be successful with deliberate practice and feedback"*). **Representation:** Select information and use tools to represent a unified, concise, and coherent analysis of the structure of a system. **Transfer*:** Apply conclusions about the structure of a system to another system (*for example: what might happen if we applied the mental models of a successful classroom to a city or town?)*

LEVERAGE ACTIONS  **Causal loops**   **Stock-flow maps and computer models**	**Identification and Explanation:** Describes the basic concept of leverage action, *i.e., an action that would bring about a desirable effect.* Identifies desirable and undesirable effects of an action. **Representation:** Labels events as a "cause" or an "effect" on a provided systems tool. **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.).* See possible student misconceptions following the rubric.	**Identification and Explanation:** Identifies potential leverage actions within a specific situation (*for example, different ways an explorer could survive in an unknown environment*). **Representation:** Depicts cause and effect relationships within a system using systems diagrams such as a stock-flow map or 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 increase their savings."*).	**Identification and Explanation:** Identifies and explains high-leverage actions that made a change within a system *(for example: when farmers in Arizona changed how they planted, the soil system was improved).* **Representation:** Represents 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 other means*). **Transfer*:** Compares and contrasts leverage action(s) in two similar systems (*for example, compares the leverage actions of General Washington in the American Revolution to the leverage actions of General Grant in the Civil War*).	**Identification and Explanation:** 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, effort needed to implement, number of unintended consequences that might result, long term efficacy of action, etc.).* **Representation:** Represent how high-leverage actions function within a system (*for example: identifying ways humans could intervene in the water cycle to create feedback which would amplify / magnify leverage in the system).* **Transfer*:** Apply conclusions about leverage actions from one system to another (*for example: similarities between actions to stop a fire and actions to stop rumors from spreading*).
BIG PICTURE  **Iceberg**	**Identification and Explanation:** Defines key terms such as" big picture", "system", and "function". **Representation:** Identifies isolated actors, parts, or events of a system (*for example: labels a diagram of the Three Branches of Government showing each*	**Identification and Explanation:** Identifies multiple parts of a system and explains the basic details or functions of the parts and how they work together (*for example: how each part of a plant serves a specific function*). **Representation:** Lists issues, goals, problems, behaviors,	**Identification and Explanation:** Identifies and explains behaviors, goals, problems, and/or relationships among parts within a system as a series of interrelated details or events (*for example: how an animal's behavior is related to its physical environment).*	**Identification and Explanation:** Explain behavior of the system as a whole: identifies and explains behaviors, goals, and/or problems within a system from a wide, "big picture" view, rather than focusing on details. Analyze interactions among multiple systems (*for example:*

 **Causal loops**  **Connection circles**	*branch, without connecting checks and balances).* **Transfer*:** Identifies one or more common attributes of how a system operates *(for example: a system can be organized and operated by one or more people or groups in some way, etc.).* See possible student misconceptions following the rubric.	and/or relationships among actors/parts within a system *(for example: a connection circle showing how parts of the system cause changes in each other).* **Transfer*:** Generalizes how the key elements of a system operate (*for example: "There is one person in control who makes many rules"*). Identifies how common elements of a system operate in two situations.	**Representation:** Creates a representation of interrelationships among parts of a system (*for example: how coyotes, rabbit and plant populations relate to one another--leaving out other factors, such as water, disease, other predators, etc.*). **Transfer*:** Applies conclusions about how one system operates to a system of a similar type (*for example: a marching band moving on a field and a military unit marching in a drill*).	*how different human body systems interact to sustain life and movement).* **Representation:** Create a representation of the system's most important set of structures and relationships by taking a whole-system perspective on an issue or process (*for example: a set of interconnected stock-flow maps or an iceberg model).* **Transfer*:** Apply conclusions about how one system operates to a system of another type (*for example: the behavior of a cell and the behavior of a factory*).
SELF-REGULATION AND REFLECTION	**Reflection:** Identifies own strengths and weaknesses as a systems thinker. **Planning:** Sets personal goals for applying systems thinking habits and tools. **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:** Assesses application of the habits and tools of a systems thinker in response to feedback and/or the rubric. **Planning:** Sets goals for applying systems thinking based on feedback and/or the rubric. **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:** Accurately reflects on the application of systems thinking habits and tools; uses reflection and/or feedback to revise thinking or to improve ideas. Questions and critiques own thinking process. Describes the learning that resulted from systems thinking. **Planning:** Seeks out, selects, and uses resources and strategies to achieve goals for improving the application of systems thinking habits and tools. **Mindset:** Demonstrates a growth mindset (the belief that	**Reflection:** Analyze patterns and trends in own thinking process. Evaluate the application of systems thinking habits and tools throughout the process. Seek out and act on feedback from peers, teacher, and experts to improve. **Planning:** Analyze patterns and prior performances to set new goals for applying systems thinking habits and tools; revise goals in response to ongoing reflection. **Mindset:** Proactively improve own areas of weakness by employing effective strategies to increase growth mindset *(for*

			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).*	*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: 3-5 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.

Possible Misconceptions: 3-5 Systems Thinking

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Students might exhibit the following misconception, belief, or perception that…		
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.

Possible Misconceptions: 3-5 Systems Thinking

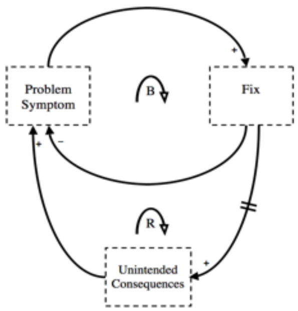
The following chart lists possible misconceptions about **Systems Thinking**. Understanding student misconceptions can help teachers develop lessons that proactively address these barriers to deep learning and transfer.

Students might exhibit the following misconception, belief, or perception that…		
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: 3-5 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.

<table>
<tr><th colspan="3">Students might exhibit the following misconception, belief, or perception that…</th></tr>
<tr><td rowspan="3">Self-Regulation and Reflection</td><td>Reflection</td><td>• 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.</td></tr>
<tr><td>Planning</td><td>• 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.</td></tr>
<tr><td>Mindset</td><td>• 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.</td></tr>
</table>



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.

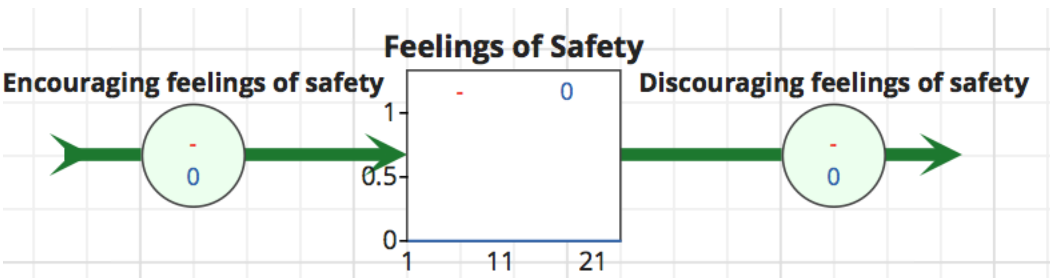
Time Delay: A gap in time between a cause and its effect within a system. Time delays may make systems hard to understand or predict.

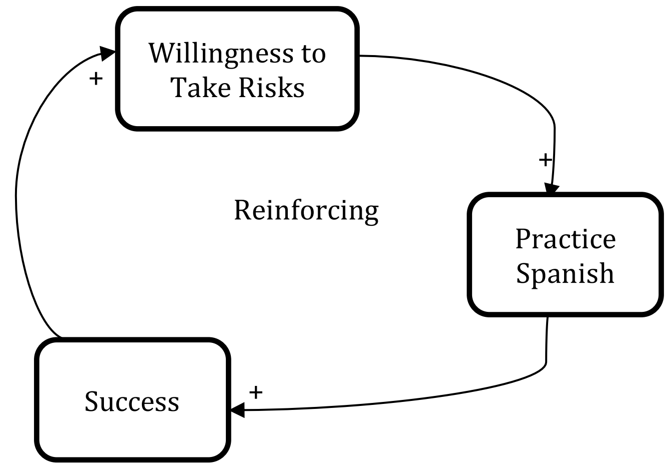
Curricular Examples for Interdependencies: The following examples may give teachers an idea of how to use stock-flow maps:

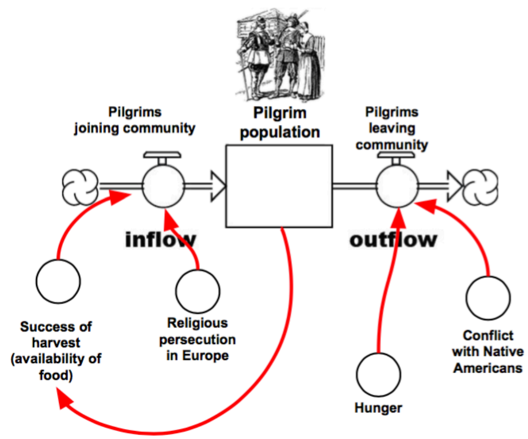
Subject Area	Stock	Flow	Converters	Potential Feedback Relationships
Science	Number of trees (Natural Resources)	• Increasing • Decreasing	• Planting new trees (increasing) • Cutting down to build houses (decreasing)	Planting trees specifically for housing instead of taking from nature (balancing feedback)
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 Revolutionary War	Number of British Soldiers in the Colonies	• Inflow/Increase • Outflow/Decrease	• Colonists' anger at the British • Deaths of soldiers • Soldiers return to UK • Conflicts with American Indians	The British mental model of what would happen: Increase in soldiers → decrease in anti-British acts → decrease in anti-British acts… (Balancing) What actually happened: As the number of soldiers increased → colonists' anger increased → Soldiers increased (England sent more to deal with angry colonists) → colonists' anger increased. . . (Reinforcing)
Math	Money in Bank Account	• Withdrawals • Deposits	• Interest • Paycheck • Mortgage/rent	In an interest generating savings account, interest is always added if there is money in the account (Reinforcing) This feedback is not present in a non-interest account.
Spanish	Feeling of Safety in a Classroom Willingness to Take	• Encouraging the feeling of safety • Discouraging the feeling of safety	• Student generated (these might include: • *Affecting the inflow* – words of encouragement, showing respect,	As a safe classroom community is cultivated → risk-taking increases Risk-taking increases → practicing

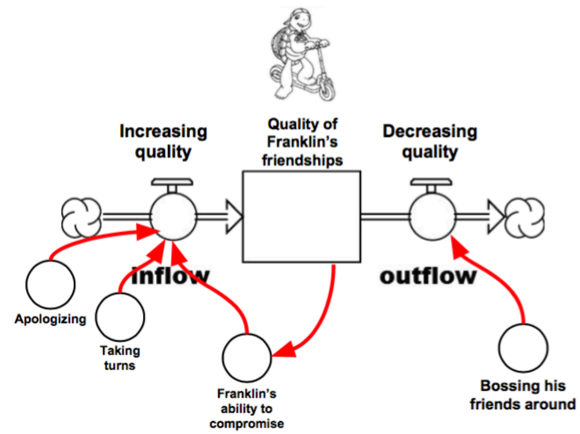
	Risks		active listening, celebrating mistakes, being kind • *Affecting the outflow* – mean comments, rude language, laughing at others' mistakes, having side conversations	Spanish increases → success increases → risk-taking increases… (Reinforcing)

This example came from a Spanish teacher at Manzanita. She would use this stock-flow map and causal loop to explain to students how a strong classroom community affects learning. She would have students share ideas for how they can encourage feelings of safety and how they could discourage feelings of safety. These ideas would become the converters on the stock-flow map.









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 • 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.

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