ENVISION 21
Deep Learning

Systems Thinking Rubric
Grades 6-8

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.

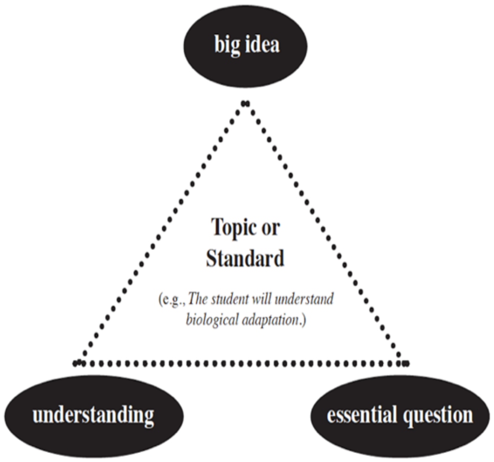
The approach to teaching the performance areas in each rubric may vary by subject area because the way in which they are applied may differ based on the field of study. Scientists, mathematicians, social scientists, engineers, artists, and musicians (for example), all collaborate, solve problems, and 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? • How can I maintain focus on areas of influence rather than on factors I cannot influence?
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.

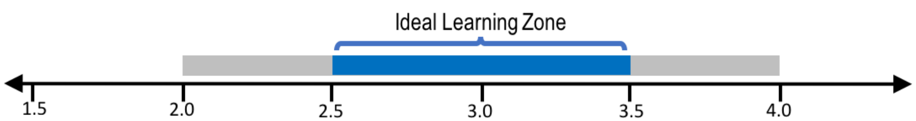
When using the rubrics to plan for instruction and assessment, teachers need to consider the knowledge and skills described in the Score 2.0 column (Basic) to be embedded in the Score 3.0 (Proficient) and 4.0 (Advanced) performance. The Novice level (Score 1.0) indicates that the student does not yet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

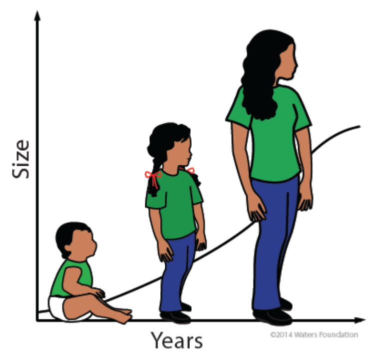
Sources

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

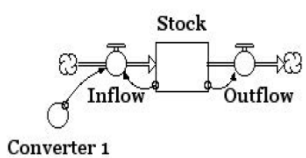
Leverage Actions, page 12

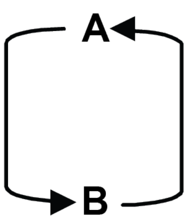
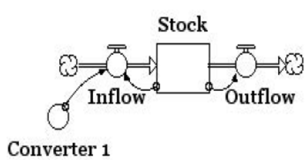
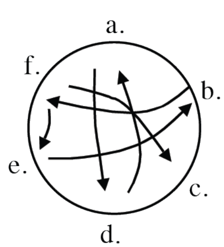
Interdependencies, page 9

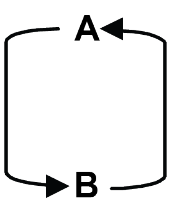
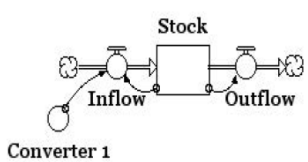
System-as-Cause, page 11

Big Picture, page 13

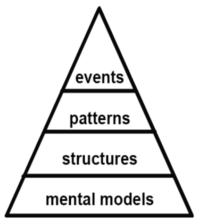
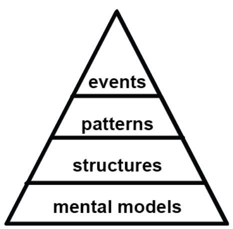
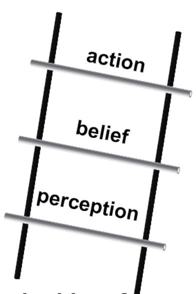
SYSTEMS THINKING

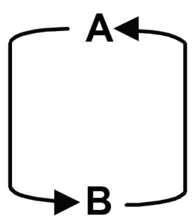
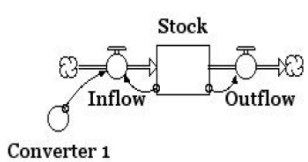
DLP Performance Area	1.0 (Novice) The student may exhibit the following readiness skills for Score 2.0:	2.0 (Basic) When presented with a grade-appropriate task, the student:	3.0 (Proficient) In addition to Score 2.0, the student:	4.0 (Advanced) In addition to Score 3.0, the student may:
CHANGE OVER TIME  **Behavior-over-time graphs**  **Stock-flow maps**	**Identification and Explanation:** Defines *accumulation*, *rate of change*, *element*, *trend*, and *pattern*. 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*:** Generalize the key elements of a situation involving change over time (*for example: "This situation involves a person whose actions are influenced by her environment." or "I see a steady increase followed by a sudden fall"*). Identifies common elements of two situations involving change over time. See possible student misconceptions following the rubric.	**Identification and Explanation:** Describes general trends in change over time. Identifies elements of the system that change over time. **Representation:** Constructs a behavior-over-time graph 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:** Describes the nature of specific trends in changes over time (*for example: a gradual increase, a sudden drop, a stepwise increase, an increase approaching a limit*). Analyzes why elements of a system change over time. **Representation:** Constructs 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). Constructs a stock-flow map to analyze why elements of a system change over time (*for example: includes individual behavior over time graphs within stocks to show behavior of the system over time*). **Transfer*:** Applies understanding of an identified change-over-time to analyze a situation of a different type that	**Identification and Explanation:** Identify and explain overarching patterns in change over time. Analyze the relationship between two or more elements that change over time. **Representation:** Create the most concise representation possible of a change over time, aggregating (generalizing) detailed information to represent the wider perspective on an issue or process. Represent change over time of more than one element, identifying specific patterns and trends. Select specific time frames or *y*-axis values to highlight particular changes, patterns, or trends. **Transfer*:** Evaluate the validity of conclusions drawn about changes within two or more systems (*for example: it may not be valid to stress the similarities of a fictional character to a*

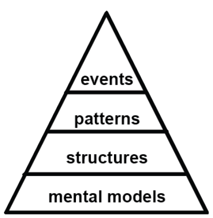
			operates in a similar manner (*for example: a fictional character's perseverance over time compared to that of an historic figure*).	*historical figure, because we don't know what historical figures are thinking; however, in some cases, diary or journal entries may reveal important truths*).
INTERDEPENDENCIES  **Causal loops**  **Stock-flow maps and computer models**  **Connection circles**	**Identification and Explanation:** Defines *feedback loop*, *reinforcing*, *balancing*, *stock*, and *causality*. Shows causal relationships as one-way, e.g., cause → effect (for example: increasing songbird populations lead to higher hawk populations[1]). **Representation:** Represents connections between the key elements of a system (*for example: uses a connection circle*). **Transfer*:** Generalizes the key elements of a system with interdependent relationships (*for example: "This system has two groups that depend on each other" or "In this system, one element reinforces another element, but balances a third"*). Identifies common elements of causal relationships in two situations. See possible student misconceptions following the rubric.	**Identification and Explanation:** Identifies and explains a single cause-and-effect loop. Distinguishes whether a loop represents a reinforcing or balancing process, or a causal relationship without feedback (*for example: as predator numbers increase, prey population decreases, which leads to decreased predator numbers…which is a balancing loop; as the number of trains in North America increased, bison populations decreased – however, changes in bison populations do not affect the number of trains…so it is a one-way causal relationship without feedback*). **Representation:** Represents a circular causal relationship between two elements of a system (*for example: uses a stock-flow map or causal loop diagram*). **Transfer*:** Applies conclusions about interdependencies in one situation to a situation of a similar type (*for example: the*	**Identification and Explanation:** Identifies and explains causality in a system of multiple connected loops. Explains the behavior over time of any stock in the system in relation to another stock *(for example: hawk, songbird, and insect populations are linked in two connected loops. See below.[2]) a reinforcing process*). **Representation:** Represents causality in a system of multiple connected loops (*for example: uses a stock-flow map or causal loop diagram*). Identifies when causality can best be represented with a stock-flow map or causal loop diagram (*for example, the interdependence between population and births can best be represented with a stock-flow map.* Represents loops that account for complex behavior beyond basic reinforcing or balancing behaviors *(for example:*	**Identification and Explanation:** Explain causal relationships and behaviors that are significant, but not obvious (*for example: the timing of a population boom in songbirds that coincides with a particular stage in the life cycle of its insect prey -- when it is dormant or pupating*). Explain loops that account for complex behavior beyond basic reinforcing or balancing behaviors *(for example: archetypes such as fixes that fail, limits to growth, or which include thresholds, time delays, etc.*). **Representation:** Create the most concise representation possible of a system, aggregating (generalizing) detailed information to represent the whole-system perspective on an issue or process. Represent causal relationships and behaviors that are significant, but not obvious. **Transfer*:** Evaluate the validity of conclusions drawn about two or more systems (*for example: it*

		increase in prey populations in response to plant increase in an ecosystem parallels the increase in bacterial growth in response to an increase in organic matter).	*archetypes such as thresholds, limits to growth, etc.*). **Transfer*:** Applies conclusions about key interdependencies in one situation to a situation of another type (*for example: the increase in prey populations in response to plant increase in an ecosystem parallels the increase of investors in a market when money is made more freely available - through interest rates, etc.*).	*may be overly simplistic to compare prey populations to investors, because investors are able to discover and communicate information about the environment which allows them to respond as a group differently than prey species).*
CONSEQUENCES  **Causal loops**  **Stock-flow maps and computer models**	**Identification and Explanation:** Defines *short-term consequences* and *long-term consequences*, *intended consequences*, and *unintended consequences*. Identifies at least one consequence for an action. **Representation:** Lists results occurring from actions. **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 problems in other areas"*).	**Identification and Explanation:** Identifies and explains short-term and/or long-term intended consequences of a particular action. **Representation:** Identifies short-term and/or long-term consequences of a particular action on a provided causal loop diagram. **Transfer*:** Applies conclusions about consequences in one situation to a situation of a similar type (*for example: consequences of two different wars*).	**Identification and Explanation:** Identifies and explains short- and long-term intended and unintended consequences that have emerged as a result of actions (*for example: Explains a case in which "the most obvious solution" made a situation worse in the long term*). **Representation:** Represents short- and long-term intended consequences through a causal loop diagram, stock/flow diagram, computer model/simulation, and/or kinesthetic activity. **Transfer*:** Applies conclusions about key consequences in one situation to a situation of another type (*for example: the effects of an antibiotic on bacteria, the effects of criticizing*	**Identification and Explanation:** 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*:** Evaluate the validity of conclusions drawn about the consequences two or more systems (*for example: students could evaluate which conclusions are valid when comparing the*

 Reviewed by Waters Center for Systems Thinking Associates

 Iceberg	Identifies common elements of actions and consequences in two situations. See possible student misconceptions following the rubric.		*someone's incorrect statement on social media*).	*decline / disappearance of ancient civilizations*).
System as Cause  Iceberg  Ladder of inference	**Identification and Explanation:** Defines *mental model* and *structure of a system.* Identifies elements of a system (*for example: in a classroom, the students, the teacher, the lesson activities, the work, and the assessments*). **Representation:** Classifies given information as observable events, patterns of behavior, structures of the system, and mental models. **Transfer*:** Identifies two systems with similarities at the level of observable events, patterns of behavior, structures of the system, or mental models. See possible student misconceptions following the rubric.	**Identification and Explanation:** Identifies a system's observable events and patterns of behavior (*for example: observation - students performing well on a test; pattern of behavior - homework completion and earlier test results; underlying structures - lesson design and peer tutoring; and mental model - "all students can be successful with deliberate practice and feedback"*). **Representation:** Describes or visually represents observable events, patterns of behavior, structures of the system, and mental models. **Transfer*:** Compares and contrasts two systems at all the levels of observable events, patterns of behavior, structures of the system, or mental models (*for example: compare / contrast communism and capitalism*).	**Identification and Explanation:** Explains how a system's underlying structures and mental models create patterns of behavior over time and 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:** Selects information and uses tools to represent a unified, coherent analysis of the structure of the system. **Transfer*:** Applies conclusions about the structure of a system to another system (*for example: what might happen if we applied the mental models underlying a communist system to a capitalist system?*).	**Identification and Explanation:** Explain the system "top-to-bottom and bottom-to-top" (i.e., from the event to the mental model level and from the mental model to the event level). Explain how the ladder of inference generates mental models. **Representation:** Create the most concise representation possible of a system, aggregating (generalizing) detailed information to represent the whole-system perspective on an issue or process. Represent a hypothetical or desired system in contrast to the current reality. **Transfer*:** Evaluate the validity of conclusions drawn about two or more systems (*for example: conclusions about improvements in capitalism drawn from communism may be difficult to*

				apply because the mental models contrast so much).
LEVERAGE ACTIONS  **Causal loops**   **Stock-flow maps and computer models**	**Identification and Explanation:** Defines "leverage action." Identifies desirable and undesirable effects of an action. **Representation:** Depicts cause and effect relationships within a system. **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" or "This system has several influential groups, each of which has its own needs and desires"*). See possible student misconceptions following the rubric.	**Identification and Explanation:** Identifies one or more potential high-leverage actions within a system. **Representation:** Labels one or more potential high-leverage actions within a system (*for example: identify all the places humans could intervene in the water cycle*). **Transfer*:** Compares and contrasts leverage action(s) in two or more systems (*for example: finding leverage actions that influence the passage of a law at the state level and at the federal level*).	**Identification and Explanation:** Explains how one or more potential high-leverage actions function within a system. **Representation:** Visually represents how one or more 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*:** Applies 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*).	**Identification and Explanation:** Surface and test assumptions about potential leverage actions within a novel context, (*for example: in a real-world context, involving student-action committees, class projects, or community involvement; or in an academic context, predicting the impact of high-leverage actions in a short story using textual evidence*), or using a model (*for example: using STELLA software*). Propose innovative and logical ways to leverage change to the system. **Representation:** Create the most concise representation possible of a system, aggregating (generalizing) detailed information to represent the whole-system perspective on an issue or process. Combine representational methods to show the impact of leverage actions (*for example: including behavior-over-time*

				graphs and feedback loops in an iceberg). Represent the outcomes of tested assumptions. Create a representation of the system that accommodates both short- and long-term impacts of leverage actions (*for example: incorporating time delays into stock/flow and/or causal loop diagrams*). **Transfer*:** Evaluate the validity of conclusions drawn about two or more systems (*for example: It might be valid to compare reduction of rumors and fire because both are best stopped by preventative measures).*
BIG PICTURE  **Iceberg**	**Identification and Explanation:** Defines *system, mental models.* Identifies and explains behaviors, goals, problems, and/or events as isolated details within a system. **Representation:** Lists issues, goals, problems, behaviors, and/or relationships among actors/parts within a system. **Transfer*:** Generalizes how the key elements of a system operate (*for example: "There is one person in control who makes many rules").*	**Identification and Explanation:** Identifies and explains behaviors, goals, problems, and/or relationships among distinct actors/parts within a system as a series of interrelated details. **Representation:** Creates a representation of individual interrelationships among parts of a system (*for example: a stock- flow map or causal loop showing how rabbit and coyote populations relate to one another - leaving out other factors, such*	**Identification and Explanation:** Explains 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. Investigates and considers the perspectives/mental models underlying the system being considered. **Representation:** Creates a representation of the system's most important set of structures and relationships by taking a	**Identification and Explanation:** Explain or predict how the system as a whole may change or develop over time. Analyze the effect of redefining the limits of the system (*for example: considering the system of courts and laws as a smaller piece of a larger system of government; for example: how does a classroom community affect and respond to changes in a school-wide community?*). Analyze interactions among multiple systems (*for example: how do the economic, social, and*

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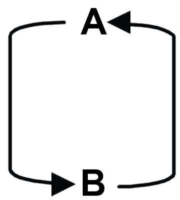
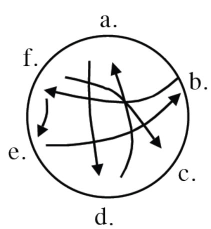
 **Causal loops**  **Connection circles**	Identifies how common elements of a system operate in two situations. See possible student misconceptions following the rubric.	*as water, plant production, disease, other predators, etc*.). **Transfer*:** Applies conclusions about how one system operates to a system of a similar type (*for example: a marching band moving on a field and a military unit marching in a drill*).	whole-system perspective on an issue or process (*for example: a set of interconnected stock- flow maps demonstrating feedback or an iceberg model).* **Transfer*:** Applies 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*).	*religious systems of ancient cultures interact with one another?*). **Representation:** Create the most concise representation possible of a system, aggregating (generalizing) detailed information to represent the whole-system perspective on an issue or process. Create an alternate representation of the system by redefining the boundaries or agents of the system, or by including actors/parts not included in previous representations (*for example: redefining the coyote/rabbit predator/ prey relationship by adding the growth of plants or the interaction of weather and seasons*). **Transfer*:** Evaluate the validity of conclusions drawn about two or more systems (*for example: the comparison is valid because a cell, like a factory, only works when all the parts within it perform their own functions, and both are dependent on receiving materials from outside*).

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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 established criteria. **Planning:** Sets goals for applying systems thinking. based on feedback and/or established criteria. **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 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:** 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 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: 6-8 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: 6-8 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: 6-8 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.

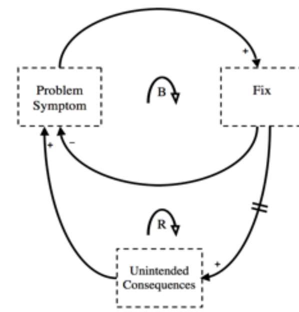
Students might exhibit the following misconception, belief, or perception that…		
Leverage Actions	**Identification and Explanation**	• All leverage actions are equally impactful. • Any action is a leverage point because it is part of the system. • A leverage point must be large and obvious. • A leverage 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: 6-8 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.

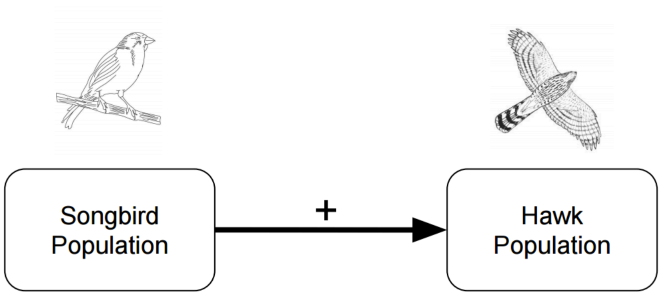
Limits: A definition of the boundaries and extent of the system, including which physical, environmental, structural, or temporal elements are relevant, and which aren’t; systems may be nested within one another. Defining the limits of a system is a crucial part of the analysis of the system.

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

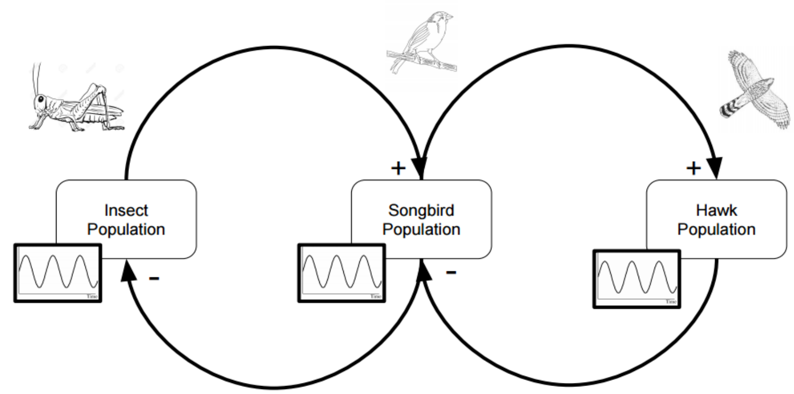
Time Delay: A gap in time between a cause and its effect within a system. Time delays may make systems hard to understand or predict.

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

Subject Area	Stock	Flow	Converters	Potential Feedback Relationships
Science	Songbird and Hawk Populations	• Songbirds born per year (increasing) • Songbirds dying per year (decreasing)	• Hawk predation • Number of fertile adult female songbirds	Hawk population (balancing feedback)

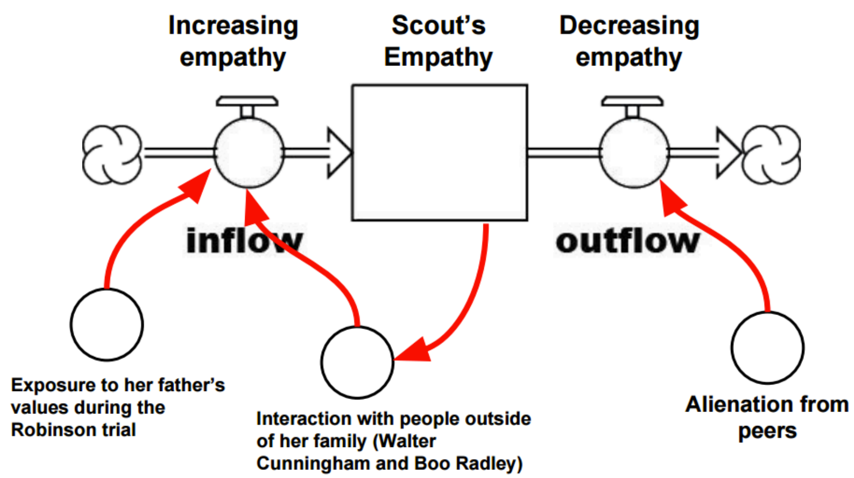


[1]*As songbird populations increase, hawk populations increase.*

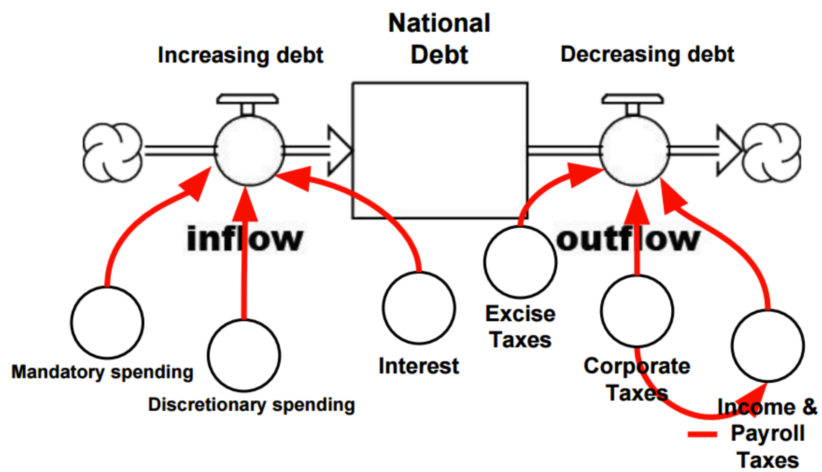


[2]*As hawks predate on songbird populations, songbird populations decrease, which allow insect populations to increase; this increase, however, has a balancing effect, allowing songbird populations to increase. Each population exists in a balancing relationship with the adjacent populations.*

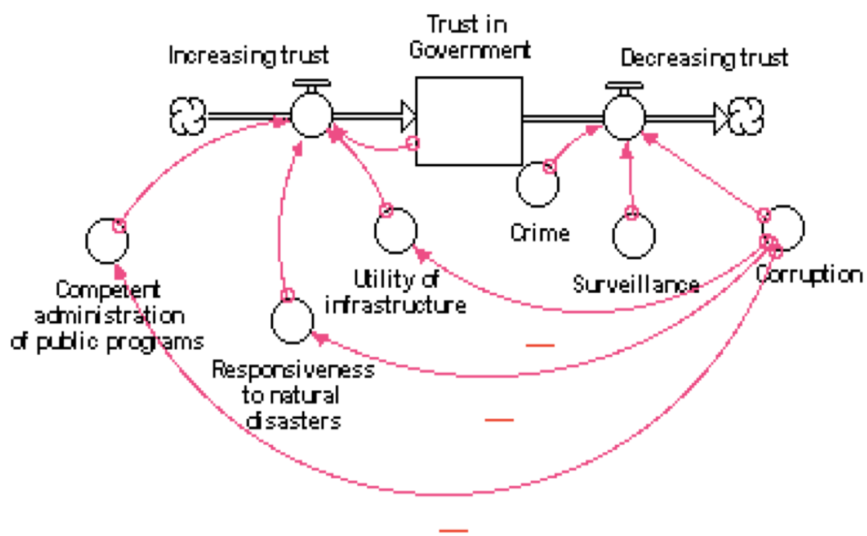
Subject Area	Stock	Flow	Converter(s)	Potential Feedback Relationships
English Language Arts	Scout Finch's level of empathy	• Increasing empathy • Decreasing empathy	• Exposure to her father's values during the Robinson trial • Interaction with people outside of her family (Walter Cunningham and Boo Radley)	Her empathy and the strength of her relationships with others (reinforcing feedback)



Subject Area	Stock	Flow	Converter(s)	Potential Feedback Relationships
Social Studies	National Debt	• Government spending (increasing debt) • Government revenue (decreasing debt)	• Kinds of Taxes • Mandatory spending: Social Security, Medicare, Medicaid, etc. • Discretionary spending: Military, Education, International Aid, Energy, etc.	• Federal Budget Surplus (reinforcing • Credit with other countries (balancing) • Corporate taxes reduce business expenditures on employees – reducing funds available through income/payroll taxes



Subject Area	Stock	Flow	Converter(s)	Potential Feedback Relationships
History	Trust in Government	• Increasing trust • Decreasing trust	• Scope of government surveillance • Competent administration of public programs	• Willingness to pay for public goods (reinforcing feedback) • Corruption erodes provision of services



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