

OVERVIEW

Earth is a dynamic place with many components and processes that interact, resulting in systems that regulate and shape the world in which we live. Students can build their own models of these systems using the [Understanding Global Change Click & Learn](#), which provides an interactive canvas for mapping and explaining global change phenomena. This Click & Learn includes a variety of Earth's components and processes across three categories: causes of change, how the Earth system works, and measurable changes.

This guide illustrates an example of how students can use the *Understanding Global Change Click & Learn* to generate and revise system models. In this context, a system model is an abstract representation that helps explain cause-and-effect relationships, and as such, are conceptual and not quantitative. An example of a system model related to ocean acidification is provided on the [Click & Learn's webpage](#).

KEY CONCEPTS

- Earth is a system with many interacting components and subsystems, such as the carbon cycle, water cycle, and nutrient cycles.
- Earth is dynamic and experiences change over both long and short timescales.
- Humans are a major cause of global change, but there are also nonhuman factors.
- Understanding how the Earth system's components and processes interact is necessary for analyzing and predicting the causes and effects of global change.

STUDENT LEARNING TARGETS

- Construct system models to investigate how small changes in the Earth system's components and processes can produce measurable global effects.

CURRICULUM CONNECTIONS

Standards	Curriculum Connection
NGSS (2013)	HS-LS2-5, HS-ESS2-4, HS-ESS2-6
AP Bio (2015)	2.D.1, 2.D.3, 4.A.5, 4.A.6, 4.B.3
IB Bio (2016)	4.1, 4.2, C.1, C.2
AP Env Sci (2013)	I.A-D, II.A-E, III.B.3, VII.B, VII.C
IB Env Systems and Societies (2017)	2.1, 2.2, 2.3, 3.1, 4.1, 5.1, 6.1, 7.2, 8.2
Common Core (2010)	ELA.WHST.9-12.1, WHST.9-12.2
Vision and Change (2009)	CC5; DP3

KEY TERMS

climate, cycle, Earth, environment, flowchart, infographic, phenomenon, process, system model, systems thinking

TIME REQUIREMENTS

One to several 50-minute class periods, depending on how the Click & Learn is used. For example, reviewing a phenomenon, learning how to use the Click & Learn, and constructing an initial system model can be accomplished in one 50-minute class period. Additional time for ongoing work, such as researching and refining models, can vary. If appropriate, students may revisit and update models periodically throughout an entire unit or course of study.

SUGGESTED AUDIENCE

- Middle School: Life Science, Earth Science
- High School: Environmental Science (General, AP/IB)
- College-level: Environmental Science, Ecology, Geology, Oceanography, etc.

PRIOR KNOWLEDGE

Students should

- be familiar with using arrows to represent cause-and-effect relationships in a diagram.
- have enough understanding of a system to map the interactions between the components of that system.

MATERIALS

- paper for student diagrams
- drawing supplies, such as pencils or markers
- UGC poster (optional and available from the [Click & Learn's webpage](#))
- computers for students to access the Click & Learn
 - The Click & Learn is best experienced on laptops (Windows, Mac OS, or Chromebooks) with an internet connection. It functions best in Firefox and Chrome browsers. Safari is supported, but with limited functionality.
 - An offline version, labeled "Desktop App," can be downloaded from the [Click & Learn's webpage](#). Students cannot save their work to Google Drive without an internet connection, but they can still save local copies of their work to their computers.

TEACHING TIPS

- Students can work individually or in groups sharing, revising, and collaborating on models.
- Consider displaying or making the poster available to students to be able to refer to the organization of the UGC framework of components.
- Consider having students begin by modeling a natural earth process, such as the water cycle or carbon cycle, so they are familiar with or have already covered in class. Examples can be used/shared from the UGC poster and/or the ocean acidification example in the accompanying zipfile. Emphasize why it is important to understand the complexities of the natural process before considering the input of additional (e.g., anthropogenic) changes.
- A printable list of the Click & Learn's components, which represent different processes and phenomena, is available as a PDF download. The printed document can be cut into cards for a classroom activity that supplements or replaces (if computer access is limited) the Click & Learn experience.
- The Click & Learn has three different styles of arrow: black, gray, and dashed. The class should reach a consensus on what each style represents. For example, you might use the different styles to connote different strengths of interactions or positive, negative, and neutral interactions. Students should be encouraged to always annotate their arrows with an explanation of the connection between the components, either on a separately or on the model for paper maps, in the app, or in the associated downloaded slides.
- The background image in the Click & Learn can be changed to any image that is relevant to the focal content. To upload an image of your choice, select "Background" from the menu, depicted by three horizontal lines, in the upper right corner of the Click & Learn.
- Students can create their own icons for components or processes not provided in the Click & Learn. They should use the icons labeled "blank," which are shown at the end of the scrollable list for each category. The label "blank" can be changed by double-clicking the icon after it is added to a model.

- Students can create an icon for themselves to represent how they personally cause changes or are affected by changes in the Earth system. They should use the human icon labeled “Your Name,” which is shown at the end of the scrollable lists for the “Causes of Change” and “Measurable Changes” categories. The label “Your Name” can be changed to the student’s name by double-clicking the icon after it is added to a model.

EXAMPLE INSTRUCTIONAL SEQUENCE

This Click & Learn is a flexible tool with many different uses. This guide provides one approach for how this tool can be used with students, but educators are encouraged to explore and create additional approaches. In this example, students first draw a concept map by hand, because it is a task they are likely familiar with. They then revise the concept map and turn it into a system model within the Click & Learn.

1. Pick a global change phenomenon that is relevant to your course. Some possible examples include:
 - a. Acid mine drainage
 - b. Animal extinction
 - c. Coral bleaching
 - d. Desertification
 - e. Drought
 - f. Eutrophication (aka dead zones)
 - g. Extreme weather events
 - h. Forest fires
 - i. Ocean acidification
 - j. Sea level rise
 - k. Stratospheric ozone depletion
 - l. Urban heat islands
2. Ask students to each draw a concept map on paper that illustrates their current understanding of the phenomenon. Prompt them to link causes and effects in their map.
3. Ask students to pair up and share their model with a peer. Each pair should then revise or combine their models based on their feedback and discussion.
 - a. At this point, you may wish to share the printable list of the Click & Learn’s components, so that students can familiarize themselves with the icons and refine their models with these components in mind.
4. Select a few groups to share their models with the entire class.
5. Wrap up the class discussion by emphasizing that a deeper understanding of global change phenomena depends on understanding connections between different components and processes within the Earth system.
6. Introduce the [Understanding Global Change Click & Learn](#). It is recommended to walk students through the “Introduction” section. In addition, you may wish to point out the following:
 - a. The circular framework graphic on the “Understanding Global Change Framework” slide is interactive. Students can zoom in on the graphic using the controls in the upper right corner. They can also click any section or icon in the graphic for more information.
 - i. Some of the clickable components include links to other BioInteractive resources containing more in-depth information.
 - ii. The graphic first appears at the end of the “Introduction” section. After completing the introduction, students can review the graphic at any time by clicking on the colored icon in the top left corner of the Click & Learn.
 - b. The “Help” menu, which appears on the black toolbar at the bottom, contains full instructions on how to build and annotate the models.
 - c. The framework contains three categories: “Causes of Change,” “How the Earth System Works,” and “Measurable Changes” in the Earth system.
 - i. To select a category, click on a colored bar at the bottom left of the Click & Learn (see Figure 1). This will bring up a scrollable list of icons that represent processes and phenomena.
 - ii. If students can’t find an icon that they need in the lists, each category also includes a blank icon that can be customized by double-clicking on it.

- d. Icons can be connected with arrows, which can then be annotated with text.
 - i. To draw an arrow between two icons, first click the arrow shown on the top right toolbar. Three style options will appear: black, gray, and dashed.
 - ii. Annotations for each arrow can be written in the list on the left.

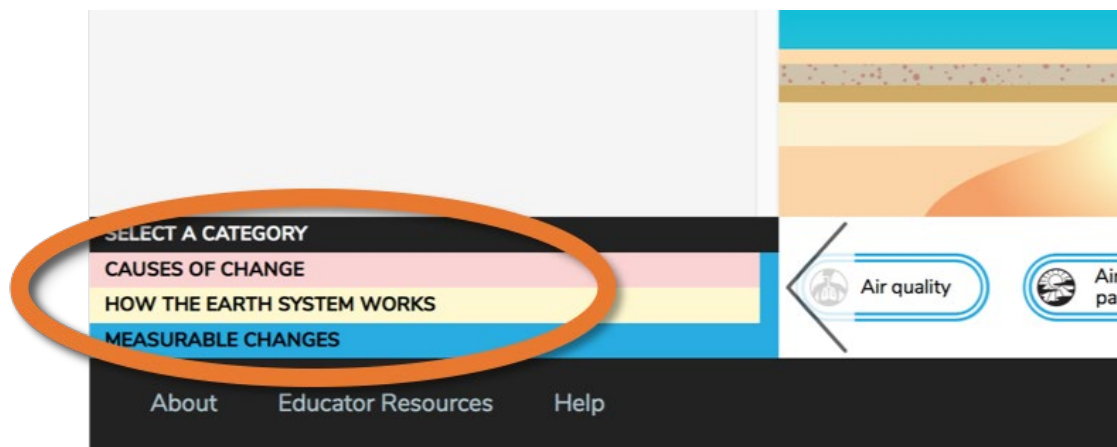


Figure 1. The three categories in the Click & Learn. Click on the categories to see the associated model components and add them to a model.

- 7. (Optional) Construct a simple model as a class to illustrate how the Click & Learn works. The model should ideally be of a process that students are familiar with or have already covered in class.
- 8. Components should be connected by arrows, and students should annotate the connections to demonstrate their understanding of each link in the model.
- 9. Have students recreate and refine their revised paper concept maps in the Click & Learn.
 - a. Models should include components from each of the three categories of processes and phenomena: “Causes of Change,” “How the Earth System Works,” and “Measurable Changes.”
- 10. Have students save and submit their final models for assessment, either as ZIP or PowerPoint files.
 - a. To save the model as a ZIP file, which can be reopened in the Click & Learn later, click on the menu icon, depicted by three horizontal bars, in the top right corner. Select whether to save the model locally on the computer or to Google Drive (see Figure 2).
 - b. To save the model as a PowerPoint, click on the icon in the top right corner, then select “Export,” followed by “Power Point.”

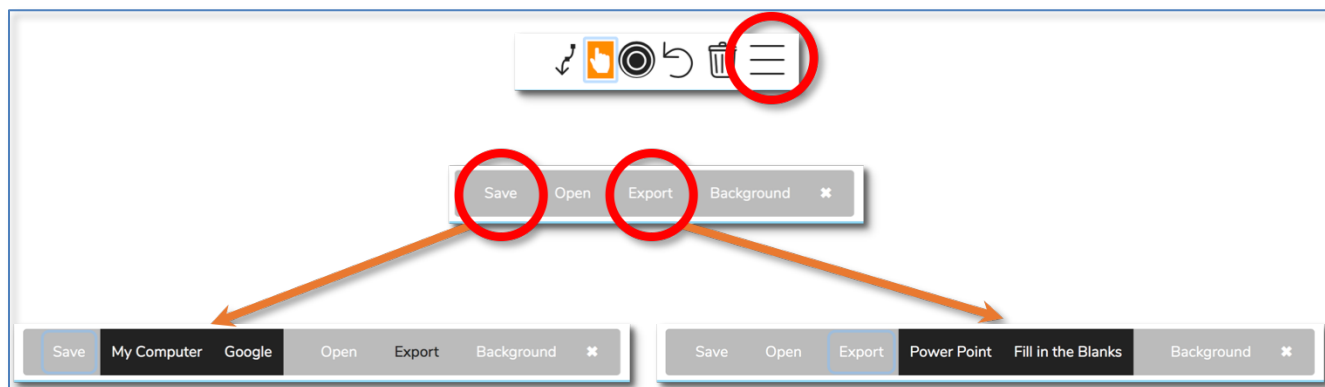


Figure 2. The menu and options for saving and exporting models in the Click & Learn.

OPTIONAL EXTENSIONS

- Have students revisit their models repeatedly over the course of a semester to elaborate on them and reflect on the changes in their understanding over time. For example, as students learn more about a topic or gain knowledge from other instructional resources, they can draw and annotate additional connections in their model. In this way, they can build more complex systems and explanations over a unit of study or across units in a curriculum.
 - Students should save their models as ZIP files (as described above) in order to edit them later. To open a saved ZIP file in the Click & Learn, click on the icon in the top right corner, then select “Open.”
- Design your own assessment by creating a fill-in-the-blank model. To do so, click the icon in the top right corner, then select “Export,” followed by “Fill in the Blanks.” This exports a PowerPoint file that shows the diagram with arrows but omits the icon labels and descriptions. You can then ask students to fill in the annotations themselves.
 - Students can open the exported file in PowerPoint or Google Slides to add annotations. Alternatively, you can print the file for a pencil-and-paper assignment.
 - Students can also use the “Fill in the Blanks” option themselves to create self-assessments as study tools.
- Pair this with the [The Anthropocene: Human Impact on the Environment Click & Learn](#), which explores anthropogenic factors of change. After completing that Click & Learn, students can build a system model of these factors using the *Understanding Global Change* Click & Learn.

AUTHOR

Mark Nielsen, PhD, HHMI

Reviewed by Aleeza Oshry, HHMI; Scott Sowell, PhD, Darnell-Cookman Middle/High School of the Medical Arts, Jacksonville, FL

Edited by Esther Shyu, PhD, HHMI