Transportation Ecosystems - Ramón L Torres

Purpose

The purpose of this activity is to have students create a conceptual model to extract information from a system, and to connect conceptual modeling practices used in transportation engineering to a middle school science class. This activity will have the students use their knowledge about ecosystems to make analogies that help them create a conceptual model of a transportation system.

Overview

Summary. The class begins with a basic review of ecosystems. The students are asked to imagine how they could model a transportation environment, e.g., an airport, as an ecosystem, where agents (vehicles, as opposed to organisms and non-organisms) interact with each other, directly or indirectly (via a third party, such as an instrument or facility), and these interactions have outcomes that can affect others in the ecosystem. As a group exercise, students create a list of agents, instruments/facilities, and outcomes of interaction at an airport. Then the teacher creates a conceptual model from the list, to show students how a conceptual model helps to explain how all the elements of the list are related to each other. The class is then divided in groups of three or four student, and each group is asked to brainstorm and create a list of agents, instruments/facilities, and outcomes for a model of their own. Then after sharing their list with the class the students create their own conceptual models, which they later present in class.

CT-STEM Skills. Students will use computational thinking throughout the lesson in several ways. In this lesson, students will

- Create a model to explain relationships between components of a transportation environment.
- Construct a model using an analogy to explain a system. They view the interaction of agents in the transportation environment as that of organisms and objects in an ecosystem.
- Use systematic thinking to establish relationships between acting agents in a system.
- Make observations of the environment and create a table of observations, which are later used to construct a graphical conceptual model.

Student Outcomes

At the end of the lesson, students will be able to:

1. Identify agents within a transportation environment/system, and create a conceptual model to explain how these interact with each other, and the outcomes of their actions.
2. Explain how different agents interact with each other in a transportation environment, and how their actions affect other agents and the surrounding environment.

Time

The lesson should take about three 40-50 minute class periods.

Level

This lesson is intended for middle school science (6th – 7th grade level).

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Materials and Tools

For each student group

1	Poster board
4	Markers (one of each, black, green, red, and blue)

Preparation

No preparation is required.

Prerequisites

Students should possess a basic understanding of ecosystems.

Background

Conceptual modeling allows us to describe some aspects of the physical and social world around us, and allow us to understand and explain it better. Conceptual models make it easier to relate how objects (animate or inanimate) interact with each other within a system.

Teaching Notes

Task 1. Discuss and review ecosystems. Ask the students what have they learned about ecosystems. They should reach the point, that in an ecosystem there are living and non-living components that interact with each other. The bottom line is that they should have the understanding that components in an ecosystem are related to one another, directly or indirectly.

Task 2. Building the bridge from ecosystems to transportation systems. Continue the discussion by telling the class that they could model a transportation system as an ecosystem. Ask the class: If we were to model a transportation system as an ecosystem, what would they look at? What would be the agents in a transportation system (analogous to organism)? What are ways in which they interact? Do they interact directly or indirectly, and if indirectly, through what means? What are outcomes of these interactions within the transportation systems? Make sure that you ask these (or related) questions in a progressive manner. The idea is to have the students think of what are the things interacting in the system, and these should be transportation agents, i.e., agents that move and affect the movement of other agents.

An airport makes a great example, as it contains many agents, instruments/facilities (that allow indirect interaction), and outcomes (see Table 1). Agents are those components of the system that are engaged in movement, e.g., vehicles, people walking, etc. Instruments/facilities are those components that allow agents to interact with each other, for example, passengers cannot just hop on a commercial airplane, they need to use a facility, such as a terminal (and a jet-bridge/stairs) to access the airplane. The same relationship holds between trains and a train stations, and buses and bus stations; these facilities are necessary to allow passengers to interact with the vehicles. An instrument such as the radiotelephone allows airplanes to communicate with air traffic control, or a radio might provide traffic reports to drivers. In terms of outcomes, there are both positive and negative outcomes related to transportation that affect the system and even other surrounding systems.

From their observations, create a table like Table 1. When making the list, it is a good idea to use different colors for the different components. Also, if using a specific legend, it is useful to use it as part of the title of the category in the list. For example, agents are written in red, and the category agent, is written inside a circular shape. This will help students to differentiate between the categories, and at the time of making the conceptual model, it will help them with the legend.

Table 1. List of agents, instruments/facilities, and outcomes.

Agents	Instruments/facilities	Outcomes
Airplanes	Terminal	Pollution
Service vehicles	Radiophone	Noise
Air traffic controller	Signs and lightning	Waste
Passengers	Radar	Movement / travel
Crew		Jobs
Helicopter		Money
Wildlife		Business
Neighbors		Accidents/incidents
Weather		
Vegetation		

Note. Students will go off on tangents and start talking about activities inside an airplane, or inside the terminal that are irrelevant within the transportation sphere. To keep them focused, remind them to think about objects that they would see if they were inside an airplane (or the terminal) and were looking out the window.

Task 3. Introduce the conceptual model. Ask the students, "If you show this to someone who is not in the class right now, do you think it would be easy for them to establish the relationships we discussed in class today?" The answer is no. The table does not include that information, another person certainly can establish relationships between the components of the list, but not necessarily the ones we discussed. If we are interested in highlighting certain interactions, we need to find a way to show it, so that it is easy to understand. Explain that a conceptual model is an abstract idea, but that we can make graphical representations to explain the interactions of all the components in the model. A useful way to show the model is to use a box diagram, or like we do here, we use a web-like graphical representation.

Develop a legend for the model. In this case I use red and circles for agents, blue and boxes for instruments/facilities, and green and diamonds for outcomes (Figure 1).

Figure 1. Legend

Using student input, i.e., the list of agents, instruments/facilities, and outcomes, create a graphical representation of the conceptual model (Figure 2). Explain how the connective lines of the model show how the components of the model are related. Writing along the lines can also show the interaction that the scientist intends to establish, further clarifying the associations. The example below is for illustrative purposes only, and it is a very basic diagram to show the educator the kind of graphical representation of the model that students should construct. A narrative follows.

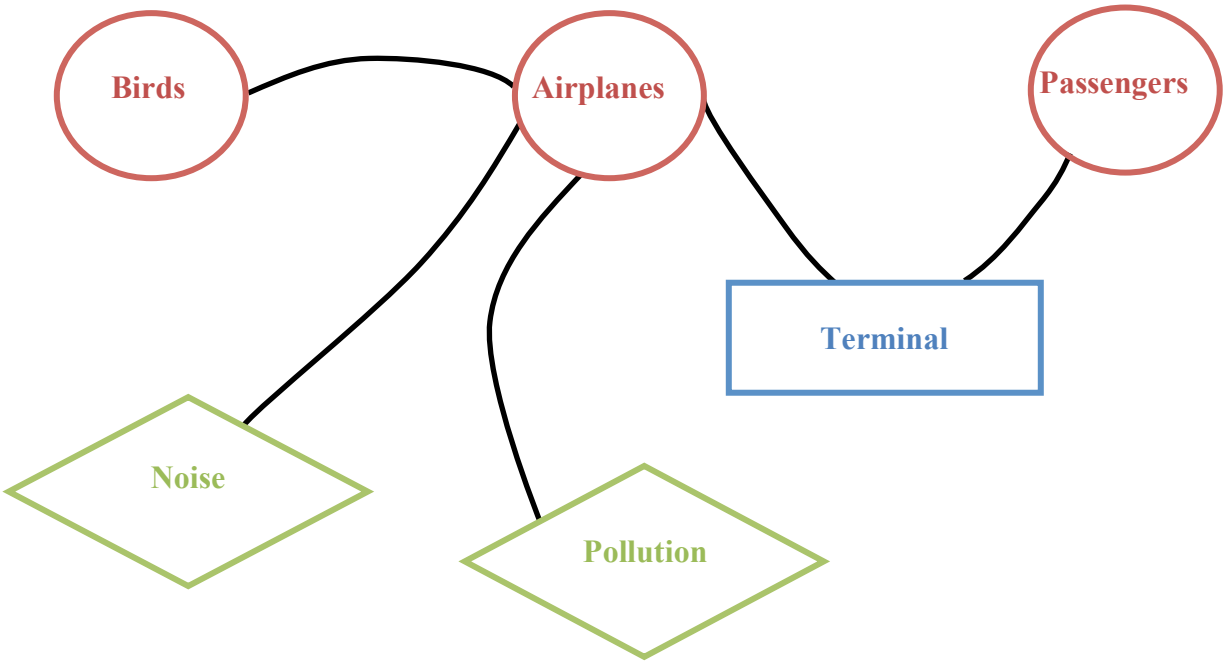

Figure 2. Graphical representation of conceptual model

Model Narrative. Let's consider three agents from the list, in this case, let's select birds (wildlife), airplanes, and passengers. So we can say that birds and airplanes interact directly with each other. A bird can fly near an airplane in movement, and in some cases, we have seen incidents in which birds are sucked into the engine. A good example of a very extreme case is that of the US Airways flight taking off from La Guardia and crash-landed in the Hudson River after flying into a flock of geese. Then we have passengers, and we know that they cannot just go on the airplane, nor they go running around the airport, so we have that passengers and airplanes interact with each other via the use of the terminal. Several outcomes of the airport are pollution and noise, which in turn, affect the system, including the birds and passengers. (Lines omitted). The terminal can also be said to produce pollution (waste from operations, or fumes from heating, cooking, etc).

Task 4. Have the students brainstorm a list of agents, instruments/facilities, and outcomes for their own model. A good way to do this is to choose something related to their daily life, i.e., ask them to model the street outside the window, and to consider, specifically, the transportation aspects of what is going on outside. They will come up with many examples that are part of their daily life. After a few minutes, have them share their lists with the class. Make a list in the board from their input.

Table 2. Example list of agents, instruments/facilities, and outcomes.

Agents	Instruments/facilities	Outcomes
Cars	Bus station	Pollution
Bicycles	Train station	Noise
People (walking)	Signs and lightning	Waste
Buses	Radio	Movement / travel
Trains	Restaurants	Jobs
Animals (wild and pets)		Money
Trucks		Business
		Accidents/incidents

Task 5. Have students create their own models in a poster board. Have the students pick up to three entries from each category (preferably from those up in the board) and create a conceptual model. They will create a web-like diagram as their model of the street outside. Then they will present their models to their entire class, and other students will have a chance to make questions in terms of their selection, and what are they trying to show to the public with their model.

Assessment

Informal assessment is conducted as part of the in-class discussion, as well as walking around the classroom while students are working in groups, i.e., brainstorming session, and when they are creating their models.

In terms of a formal assessment, students will create their poster boards, and have to explain their models, at which point the floor is open for questions from the teacher and/or students.

- Where the students able to produce reasonable (realistic) associations in their model?
- Where the components of the model relevant to a transportation system?
- Were the students able to explain their reasoning behind the choices in the model?
- Did the students use an appropriate legend?