**Habits of a Systems Thinker**

**Summary:**

This lesson introduces some of the skills and concepts involved with Systems Thinking.

**Systems Thinking** is ‘a holistic approach to the identification and solving of problems where the focal points are treated as components of a system, and their interactions and interrelationships are analysed individually to see how they influence the functioning of the entire system.' ([Key Ideas – Technologies, Australian Curriculum](https://www.australiancurriculum.edu.au/f-10-curriculum/technologies/key-ideas))

Students are introduced to a number of Habits of a System Thinker, positive and negative feedback loops and the concept of supra- and subsystems.

**Year level**: 7-8; 9-10

## Biosphere 2 Tour (World's Largest Earth Science Experiment) , Oracle, Arizona: Look Who's TravelingLearning hook

Credit: [Looks Who’s Blogging](https://www.youtube.com/channel/UCleKsM8arVjfE1GIaklqGRw)

Watch the [short video about Biosphere 2](https://www.youtube.com/embed/UxEZpo5JR7c?feature=oembed).

Biosphere 2 is an example of a **system**: a collection of parts that are arranged and connected in a specific way. Interactions between the parts within the system, and between systems, influence the stability of the system as a whole.

It's possible to have a collection of items that don’t form a system, such as appliances in a kitchen. As they are not interdependent, the removal of a toaster will not stop the fridge from working. Similarly, the order in which you place items in a backpack does not affect the usability of each item – they are a collection of items but not a system, because there is no interconnectedness.

As a class, be guided by these questions and activities.

1. What was an overarching goal of the Biosphere 2 experiment?
2. Try to list as many parts or components of the system (when the experiment took place) as you can. Consider plants, animals, gases, liquids, energy and soil.
3. Lower than ideal oxygen levels were a recurring problem during the experiment, and they affected the animals – including the humans. Speculate: What do you think might have caused this?

### Suggested answers:

One suggested cause is the adding of rich farming soil to help boost initial food production when the experiment began. The soil consumed or absorbed more oxygen than the rest of the internal ecosystem could balance out, so oxygen had to be pumped in.

This example shows how causes of problems within a system are often not immediately apparent, and may sometimes only be revealed with observation over time. The designers of Biosphere 2 correctly predicted that many of the added plants and animals would not survive the early stages of the experiment, but may not have foreseen this disruptor.Learning map and outcomes

## Learning map and outcomes

In this lesson, students will:

1. identify and define a system
2. identify and define habits of a Systems Thinker
3. find appropriate examples for the application of Systems Thinking habits
4. explore the concept of positive and negative feedback loops
5. identify subsystems and suprasystems
6. apply Systems Thinking habits to an example of digital technologies impact

## Learning input

A systems thinker aims to understand the relationships within a system, and the impacts on other systems. By using a wide perspective and tracing interrelationships, systems thinkers can ‘join the dots’ to draw conclusions or make predictions. This is because they note events and patterns of behaviour and understand how these are caused by system structures such as feedback loops. They view things in circles rather than in straight lines. Systems thinkers use tools to help with their thinking such as causal loop diagrams and models.

1. With students in pairs, allocate one of the Habits of a Systems Thinker cards from the [Waters Center for Systems Thinking](https://waterscenterst.org/systems-thinking-tools-and-strategies/habits-of-a-systems-thinker/) to each pair. Download the [cards as a PDF](http://www.digitaltechnologieshub.edu.au/docs/default-source/ai-lessons/habits-of-a-systems-thinker/habits-of-a-system-thinker-cards.pdf).
2. Ask students to view the text and image carefully.
3. Allocate each pair 10 minutes to prepare a one-minute explanation of how this example illustrates a habit of a systems thinker for the rest of the class. Students use this [Habit worksheet](http://www.digitaltechnologieshub.edu.au/docs/default-source/ai-lessons/habits-of-a-systems-thinker/habit-worksheet-v0-02f2a44c9809f96792a599ff0000f327dd.pdf) to record their ideas in preparation for their explanation.
4. Have a general discussion how these habits might relate to the Biosphere 2 experiment.

## Learning construction

### **Negative feedback loops**

Feedback loops are an important element in systems thinking. There are two types of feedback loops that help explain how changes have happened within a system and why. Loops imply that feedback works in circles rather than in straight lines.

When a change is happening in a system, a **negative feedback loop** tends to dampen or buffer the change, leading to more stability. Despite the name, this is often a ‘good’ thing!

The **causal loop diagram** shows that A causes B, but B has a balancing or stabilising effect on A.

The table below includes three examples of negative feedback loops. As a class, develop some other examples.

|  |  |  |  |
| --- | --- | --- | --- |
| **System** | **Change** | **Negative feedback** | **Effect** |
| Human body | Exercise heats up the body | Sweat glands activate | Body more likely to cool |
| Oven with thermostat | Thermometer detects temperature is too high | Heating element is lowered or deactivated | Temperature reduces |
| Online shop | Increasing number of shoppers entering invalid addresses | Data validation added to confirm streets with existing database | Reduced number of invalid addresses |
|  |  |  |  |
|  |  |  |  |

### Positive feedback loops

When a change is happening in a system, a **positive feedback loop** amplifies or exacerbates the change. This means that change will continue in the same direction, reinforcing its effect. Despite the name, this is often a ‘bad’ thing, because it has the potential to make the system less stable over time. If positive feedback loops continue, a system may undergo ‘boom and bust’ cycles, unravel to a lower level of complexity, or collapse completely.

The table below includes two examples. As a class, develop some other examples\*.

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|  |  |  |  |
| --- | --- | --- | --- |
| **System** | **Change** | **Positive feedback** | **Effect** |
| Earth's atmosphere\* | More temperature extremes due to climate change | Melting of permafrost releases methane | More methane in the atmosphere accelerates climate change |
| Supermarket and shoppers | Warning about impending stock delivery shortages due to unpredicted event | Panic buying | Stock items sell faster |
|  |  |  |  |
|  |  |  |  |

\* Teachers may highlight here that many systems like the atmosphere are very complicated and not fully understood. Both positive and negative feedback loops exist in our biosphere, and this is just one feedback loop that has been identified.

### Subsystems and supra systems

It is often possible to identify **subsystems**, smaller systems operating within a larger one. For example, in the context of a video-sharing social media platform, an individual smartphone can be seen as a system with interconnected functions – taking photos and videos, using the app, playing music. But even the photo and video functionality is itself a subsystem with interdependent hardware (the camera) and software components (apps and image processing algorithms).

The smartphone is also part of a **supra system**, relying on the internet for many of its functions, interacting with users, commercial entities, developers and more.

A simplified diagram showing photo and video functionality as a **subsystem** of a smartphone system in the context of a social media platform for video sharing. The system is itself part of a **supra system** showing components of the social media platform. (Note, the smartphone is part of many other supra systems.)

Consider other systems now – this time systems of the human body. As a class, complete these statements with **subsystem** or **supra system**.

* The nucleus is a \_\_\_\_\_\_\_\_\_\_\_\_\_\_ of a cell.
* The liver is a \_\_\_\_\_\_\_\_\_\_\_\_\_\_ of cell systems working together.
* Relative to the liver, the digestive system is a \_\_\_\_\_\_\_\_\_\_\_\_\_\_ .
* The digestive system is a \_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the human body.

### Users as part of digital systems

### When describing digital systems or information systems, systems thinkers acknowledge that hardware, software and data are not the only components of the system. Users must also interact with parts of a system, usually by following procedures and using interfaces.

### Understanding the interactions of a user within a digital system is critical to the development of effective user experience.

### Impact of digital innovations

Technology can have far-reaching impacts on cultures, economies and the environment. Think of the impact of older information technologies, like the alphabet or the printing press! Newer information technologies enabled by digital computing are also having impacts on many different systems.

As a class, revise the habits of a systems thinker (see the ‘Learning input’ section) by listing them:

|  |  |
| --- | --- |
| Seeks to understand **the big picture** | Observes how elements within systems **change over time**, generating patterns and trends |
| **Considers an issue fully** and resist the urge to come to a quick conclusion | Uses understanding of a system structure to identify possible **leverage actions** |
| Checks results and changes actions if needed: **‘successive approximation’** | Surfaces and tests assumptions |
| **Changes perspectives** to increase understanding | Identifies the **circular nature** of complex cause and effect relationships |
| Recognises the impact of **time delays** when exploring cause and effect relationships | Considers how **mental models** affect current reality and the future |
| Recognises that a system's **structure generates its behaviour** | Considers **short-term and long-term consequences** of actions |
| Pays attention to **accumulations** and their rates of change | Makes **meaningful connections** within and between systems |

Ask students to do the following, using the habits of a systems thinker:

* Choose *one* of the rows in the table below or come up with your own approved topic.
* Identify one or more supra systems or connected systems affected by the changes the chosen innovation has made to the chosen system (e.g. passengers and drivers using peer-to-peer ride sharing are part of a transport supra system, including private cars, public transport and taxi services).
* Write a list of known impacts from the chosen innovation on the chosen system and on the supra system/connected systems. Consider both of these things:
	+ two different perspectives within the system
	+ two different perspectives from the supra system / connected systems.
* Write a list of any future, potential impacts you foresee as the technology continues to be used and/or developed.

|  |  |
| --- | --- |
| **Innovation** | **System** |
| peer-to-peer ride sharing (e.g. Uber) | passengers and drivers |
| content recommender systems (e.g. YouTube or newsfeeds)  | users and content providers |
| face recognition AI | passengers and airport security |
| home streaming services (e.g. Netflix) | home video viewers and content providers |
| app-based food delivery (e.g. Uber Eats) | restaurants, deliverers and customers |
| social media (all, or choose a specific type) | users and content creators |
| spell-check and autocorrect | students and teachers |
| ‘swipe’ dating apps\*\* | single people and app providers |

\*\* Teacher should exercise caution and awareness of student sensitivities before presenting this as an option. However, this may be a useful tie-in to health topics.

### Suggested answers:

Chosen innovation: **app-based food delivery**

Chosen system: **restaurants, deliverers and customers**

Supra systems: **dining industry**, **commercial property**, **parking and road use**

Known impacts:

* Restaurants must adjust or absorb prices to participate in new technology. This may also impact on traditional eat-in or takeaway customers.
* ‘Dark kitchens’ or ‘virtual restaurants’ appear to compete with traditional restaurants. Lower property costs and fewer overheads (e.g. staff to serve customers directly or seat them).
* Customers may not favour local restaurants or recognise localised presence.
* Customers may eat out less frequently. They now have access to delivery of meals that were previously only available via eat-in or takeaway.
* Deliverers take up car parking spaces near restaurants while waiting for food to pick up.
* As part of the Gig Economy, deliverers may not receive the employment security or benefits of traditional restaurant employees.

Possible future impacts:

## Fewer restaurants open to the public. Leads to less-active streets and local communities, particularly at night. This could increase local crime. Customers less inclined to go out at night = positive feedback loop!

## Commercial property affected by fewer active restaurants.

## Local character less critical to restaurant success, leading to homogenisation of offerings and possibly more chains and franchises.

## Deliverers more motivated to reduce transport costs than traditional customers, driving an increase in scooters and bikes instead of large cars.

## Resources

* Video: [Biosphere 2](https://www.youtube.com/embed/UxEZpo5JR7c?feature=oembed)
* Website: [The Waters Center for Systems Thinking](https://waterscenterst.org/systems-thinking-tools-and-strategies/habits-of-a-systems-thinker/)
* Video: [Systems Thinking](https://www.youtube.com/watch?v=J7mrhSlNPEQ) video for teachers from CSER (University of Adelaide)
* Habits Worksheet [PDF](http://www.digitaltechnologieshub.edu.au/docs/default-source/ai-lessons/habits-of-a-systems-thinker/habit-worksheet-v0-02f2a44c9809f96792a599ff0000f327dd.pdf)/ [Word](http://www.digitaltechnologieshub.edu.au/docs/default-source/ai-lessons/habits-of-a-systems-thinker/habit-worksheet-v0-02.docx)

## Assessment

This lesson includes a worksheet (see **Learning Input**) and a final task (see **Impact of Digital Technologies**).

These items can be used for formative assessment purposes towards the relevant achievement standards below.

Additionally, a self-assessment sheet for reflection is available in [Word](http://www.digitaltechnologieshub.edu.au/docs/default-source/ai-lessons/habits-of-a-systems-thinker/self-assessment---habits-of-a-systems-thinker-v0-02eda44c9809f96792a599ff0000f327dd.docx) or [PDF](http://www.digitaltechnologieshub.edu.au/docs/default-source/ai-lessons/habits-of-a-systems-thinker/self-assessment---habits-of-a-systems-thinker-v0-02.pdf) format. Skills to be circled on the sheet each relate to activities in this lesson idea.

Links with **Achievement standards**:

| **Year** | **Achievement standard** |
| --- | --- |
| Years 7 and 8 | "By the end of Year 8, students explain how social, ethical, technical and sustainability considerations influence the design of innovative and enterprising solutions to meet a range of present and future needs. They explain how the features of technologies influence design and production decisions.""They develop criteria for success, including innovation and sustainability considerations, and use these to judge the suitability of their ideas, solutions and processes." |
| Years 9 and 10 | "By the end of Year 10, students explain the control and management of networked digital systems and the security implications of the interaction between hardware, software and users.""They evaluate information systems and their solutions in terms of risk, sustainability and potential for innovation and enterprise." |

## Curriculum links

### Links with Digital Technologies Learning Area:

| **Strand** | **Year** | **Content Description** |
| --- | --- | --- |
| Processes and Production Skills | Years 7 and 8 | Evaluate how student solutions and existing information systems meet needs, are innovative, and take account of future risks and sustainability ([ACTDIP031](https://www.australiancurriculum.edu.au/Search/?q=ACTDIP031))Design the user experience of a digital system, generating, evaluating and communicating alternative designs ([ACTDIP028](https://www.australiancurriculum.edu.au/Search/?q=ACTDIP028)) |
| Years 9 and 10 | Evaluate critically how student solutions and existing information systems and policies, take account of future risks and sustainability and provide opportunities for innovation and enterprise ([ACTDIP042](https://www.australiancurriculum.edu.au/Search/?q=ACTDIP042))Design the user experience of a digital system by evaluating alternative designs against criteria including functionality, accessibility, usability, and aesthetics ([ACTDIP039](https://www.australiancurriculum.edu.au/Search/?q=ACTDIP039)) |

### Links with General Capabilities:

| **Capability** | **Element / Sub element** | **Content description** |
| --- | --- | --- |
| [Information and Communication Technology (ICT)](https://www.australiancurriculum.edu.au/f-10-curriculum/general-capabilities/information-and-communication-technology-ict-capability) | Applying social and ethical protocols and practices when using ICT / Identify the impacts of ICT in society | *Typically by the end of Year 8, students:*explain the benefits and risks of the use of ICT for particular people in work and home environments.*Typically by the end of Year 10, students:*assess the impact of ICT in the workplace and in society, and speculate on its role in the future and how they can influence its use |
| [Critical and Creative Thinking](https://www.australiancurriculum.edu.au/f-10-curriculum/general-capabilities/critical-and-creative-thinking/) | Generating ideas, possibilities and actions / Seek solutions and put ideas into action | *Typically by the end of Year 8, students:*predict possibilities, and identify and test consequences when seeking solutions and putting ideas into action*Typically by the end of Year 10, students:*assess risks and explain contingencies, taking account of a range of perspectives, when seeking solutions and putting complex ideas into action |
| [Ethical Understanding](https://www.australiancurriculum.edu.au/f-10-curriculum/general-capabilities/ethical-understanding/learning-continuum/) | Reasoning in decision making and actions / Consider consequences | *Typically by the end of Year 8, students:*investigate scenarios that highlight ways that personal dispositions and actions can affect consequences.*Typically by the end of Year 10, students:*analyse the objectivity or subjectivity behind decision making where there are many possible consequences |