# Raspberry Pi Foundation

Pedagogy Quick Read

Using concept maps to capture, communicate, construct, and assess knowledge

Concept maps are "graphical tools for organising and representing knowledge".[1] Fundamentally, they consist of concepts and the labelled links between them, which together describe knowledge in the form of statements or propositions. In education, concept maps can capture the knowledge of subject experts, educators, and learners, so they can be used for planning, teaching, learning, and assessment.
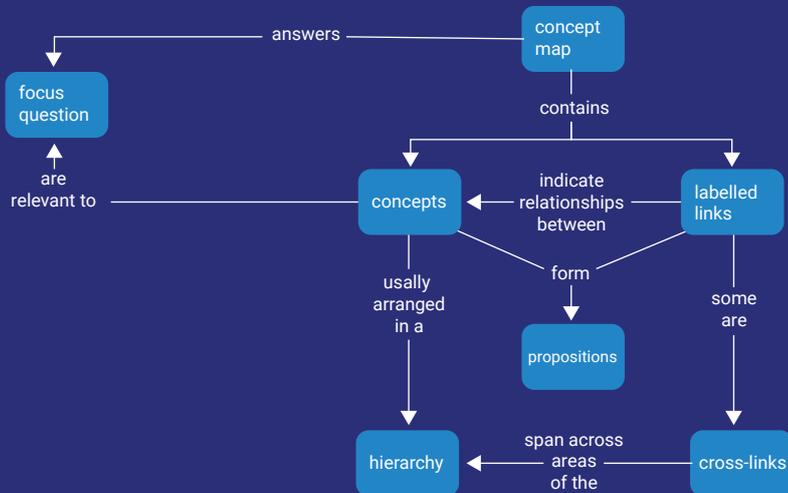
What they are

Concept maps are tools for representing knowledge visually, as an interconnected network of **concepts**. The **links** connecting the concepts are labelled (unlike in mind maps) to specify the **relationships** between them. Therefore, any transition between concepts over a labelled link forms a short **proposition** or unit of meaning.

Concepts may be structured in a **hierarchy**. Links that span across different branches of the hierarchy are called **cross-links**, and uncover deeper connections. A concept map captures knowledge relevant to a **focus question** that provides context for the map and helps direct its construction and comprehension. Some nodes in a map may not correspond to concepts, but rather, may be concrete **examples** of concepts.

Concept maps are a means for "externalising cognition, making mental models visible so that they can be compared and combined".[2] As such, they can be useful for representing the knowledge of both educators and learners, making them a versatile educational tool.

Key benefits

Components

- **Concepts**, which are often arranged in a **hierarchy**, form the basis of concept maps.
- **Links** connect the concepts to indicate a relationship between them. **Cross-links** are links across different branches of the hierarchy.
- **Labels** on the links (usually verbs) specify the relationships between the concepts.
- A **focus question** provides context for the concept map and guides its construction.
- **Propositions** or **units of meaning** are formed by following a link from one concept to another, e.g. "A concept map answers a focus question".
- **Examples** are instances of concepts that may be included to make concepts clearer and more concrete.

Construction:

- Determine the **focus question**.
- List (and possibly order) the relevant concepts in a **parking lot**.
- **Connect** concepts from the parking lot to form **propositions**.
- **Rearrange** and **refine**.

Applications

- Informing the planning of learning experiences
- Facilitating communication and collaboration between educators
- Presenting or summarising information for learners
- Supporting learners to connect new information to existing knowledge
- Helping educators to assess prior knowledge, misconceptions, and assimilation of new information

For concept maps to have a positive impact, they need to be a fully integrated feature of the teaching and learning process.

How to make them

Here at the Raspberry Pi Foundation, we use concept maps as part of our planning process. You can find examples online and a guide to constructing them below.

Determine the focus question: Specify what the knowledge represented in a concept map will be about. The focus question can be broad, such as "How are images represented using binary digits?" or specific, such as "How does this piece of code work?".

Populate the parking lot of concepts: Determine the list of concepts, ideas, or keywords that are relevant to the focus question. If it makes sense, order them according to how general they are, or how relevant they are to the focus question. This is the first step towards structuring the concepts into a hierarchy.

Explore the relationships between concepts: Link related concepts and label the links to specify their relationships. This essentially amounts to forming propositions that connect the concepts.

Improve and refine: Building concept maps is always an iterative process, and concept maps should never be considered finished.

In education, the process of constructing a concept map (and even that of reading and interpreting it) must be demonstrated by the educator. Building a concept map can also be a collaborative activity.

How they can be used in education

Educators can use concept maps to capture the knowledge that they aim to convey to their learners. Concept maps have a specific structure, which places restrictions on their expressive power. Therefore, in order to represent knowledge with a concept map, educators have to break that knowledge down into short propositions. This is a challenging but illuminating process of introspection and iterative refinement that will help them create a representation of their teaching content in a simple, distilled form.

Concept maps that capture subject knowledge can be used by educators in a variety of ways. They can inform the **planning** of a lesson or sequence of lessons. They can serve as a means of **communication** with other educators, especially if they are drawn collaboratively. They can also be used to support **teaching** and **assessment**.

Concept maps can be presented to learners as a supplementary way to **provide or summarise information**. Educators should start with a minimal skeleton map that will be iteratively extended when new knowledge is introduced, which will support learners to organise this new information and connect it to existing schemas. Concept maps can also be used as study guides and revision tools.

Concept maps can be used for **assessment** in a number of ways. For example, educators could ask learners to fill in concepts or links, or to extend an existing concept map. Learners could repeat this process over several lessons: they could start with a parking lot of concepts, which they could then incorporate into their concept maps as the lessons progress. This would help identify misconceptions or unassimilated concepts in every step, as learners' concept maps provide insights into their understanding. Educators could use these activities to aid recall or assess prior knowledge, or to prompt learners to summarise new concepts whilst connecting them to form propositions.

Concept maps should be tightly integrated into the teaching and learning process, and they should only be used for assessment if they have been consistently used in teaching.

Why they should be used

There is sufficient evidence to suggest that an **integrated** use of concept maps in teaching can be beneficial to learners, especially less confident learners, or learners who struggle with reading. [3, 4, 5]

Concept maps represent knowledge visually, highlighting the structure and the connections between concepts. Their potential to enhance learning, retention, and transfer is often linked to **cognitive load theory**: as learners struggle to identify concepts, and as the connections between concepts place a burden on working memory, concept maps facilitate schema construction by "serving as a kind of template or scaffold to help organize knowledge and to structure it, even though the structure must be built up piece by piece".[1] This links back to the suggestion that concept maps should be developed iteratively, through "an orderly sequence of iterations between working memory and long-term memory, as new knowledge is being received and processed".[1]

References

1. Novak, J. & Cañas, A. (2008) *The Theory Underlying Concept Maps and How to Construct and Use Them*. Florida Institute for Human and Machine Cognition. Technical Report IHMC CmapTools 2006-01 Rev 01-2008.

2. Wilson, G. (2019) *Teaching Tech Together*. Boca Raton, USA, CRC Press. teachtogether.tech/#s:memory-concept-maps

3. Nesbit, J. & Adesope, O. (2006) Learning With Concept and Knowledge Maps: A Meta-Analysis. *Review of Educational Research*. 76 (3), 413–448

4. Horton, P., McConney, A., Gallo, M., Woods, A., Senn, G. & Hamelin, D. (1993) An investigation of the effectiveness of concept mapping as an instructional tool. *Science Education*. 77 (1), 95–111

5. Cañas, A., Coffey, J., Carnot, M., Feltovich, P., Hoffman, R., Feltovich, J. & Novak, J. (2003) *A Summary of Literature Pertaining to the Use of Concept Mapping Techniques and Technologies for Education and Performance Support*. Florida Institute for Human and Machine Cognition. Report prepared for the Chief of Naval Education and Training.

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