

Organising knowledge with multi-level content:

Making knowledge easier to understand, remember and communicate

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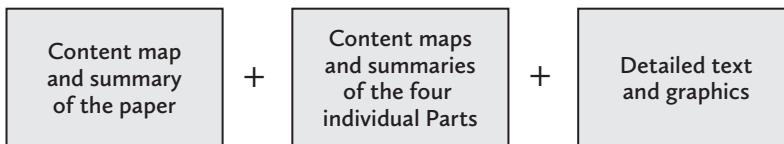
Introduction

The purpose of this paper is to introduce the concepts of knowledge maps, hierarchical knowledge organisation and multi-level content, and explain the potential they bring to making knowledge easier to understand, remember and communicate.

STRUCTURE OF THE PAPER

To improve readability as well as to illustrate the concept of multi-level content, the paper has:

- a one-page content map and summary of the paper as a whole
- 10 pages providing content maps and summaries for each of the four different Parts of the paper
- the detailed text and graphics.



Some readers will want to read the summaries first before going on to the detailed text so they can decide whether the detailed text is worth more of their time. Others, possibly mindful that there is a certain amount of repetition between the summaries and the detailed text, may want to start with a fresh read of the detailed text and then move back to the summaries for a review.

I don't want to suggest that I have provided a definitive interpretation of how multi-level content might look. As with sketchnotes, there will be many different styles of multi-level content, balancing text and graphics in different ways.

TWO DEFINITIONS

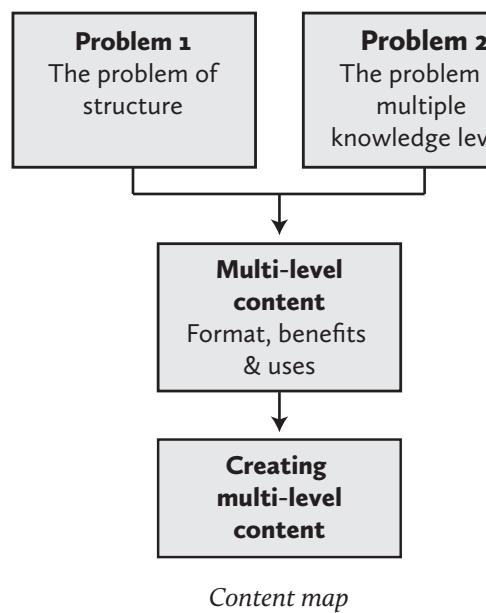
I am using a wide definition of 'knowledge'. I believe my analysis applies not just to the core areas of human knowledge like history, physics, medicine or philosophy but also to specific arguments being made for particular viewpoints as well as more simple descriptions of reality such as geographical directions.

I am using 'learners' here as a generic term for anyone encountering new information. This could include pupils and students, a reader of a non-fiction book, someone watching a YouTube lecture, an attendee at a presentation, or even someone being given simple instructions.

A PROGRESSION FROM MULTI-LEVEL SUMMARIES

This paper is a development of the ideas discussed in my earlier blog posts on the application of multi-level summaries to non-fiction books – [Part 1](#) and [Part 2](#).

ORGANISING KNOWLEDGE: SUMMARY OF PAPER



Summary

i. Two key problems for learners and those who want to communicate knowledge are:

- the problem of structure
- the problem of multiple knowledge levels.

The problem of structure

2. All knowledge has structure. Each description, concept, idea or argument is made up of different knowledge elements which are deliberately structured in a way that will best express the meaning that the speaker or writer wants to communicate.

3. Making sense of any knowledge requires understanding the structure of the explanation. However neither spoken or written words on their own are very effective at communicating structure.

4. Without visual representations of knowledge structures, more cognitive energy is required to decipher what has been described in speech or text.

For complex explanations, this can be demanding and leaves less energy available for the critical processes of understanding, reflecting and remembering.

The problem of multiple knowledge levels

5. Knowledge does not just have structure, it has hierarchical structure.

Complex explanations need multiple connected levels, organised by detail and importance, if learners are to be able to understand them.

6. The top levels of an explanation provide the big picture summary that draws together the threads of an argument or description. They also outline the more important elements of an explanation.

The lower levels in the hierarchical structure provide the essential detail and the subsidiary information.

7. Problems can arise when these multiple knowledge levels are either not explicitly differentiated or there are levels or parts of levels missing.

A key aspect of learning is being able to move easily between the big picture or the wider context and the detail (and between the core information and the subsidiary information) in order to build up an understanding of what one is learning.

Learners can struggle if descriptions of the big picture or the core information are not marked out clearly but are instead hidden in a mass of detail – or are missing.

8. Different people also have different needs. Some may only require the big picture summary or an outline of the most critical elements. Others will also require more detail or subsidiary information.

In addition, individuals may have different needs at different times. Someone starting a new book might

welcome a general overview of the contents of the book before they are ready to immerse themselves in the detail.

9. Undifferentiated or missing knowledge levels add more cognitive friction as learners struggle to find the appropriate knowledge level or levels for their needs.

Potential solutions

10. A solution to the problem of structure is to create knowledge maps which provide visual representations of knowledge structures, using diagrams, tables and representational graphics, alongside category names and descriptions.

11. A solution to the problem of multiple knowledge levels is to create explicit differentiation of existing knowledge levels or to add in missing ones by providing summary explanations.

12. The concept of multi-level content combines these two solutions with the provision of both knowledge maps and summary explanations.

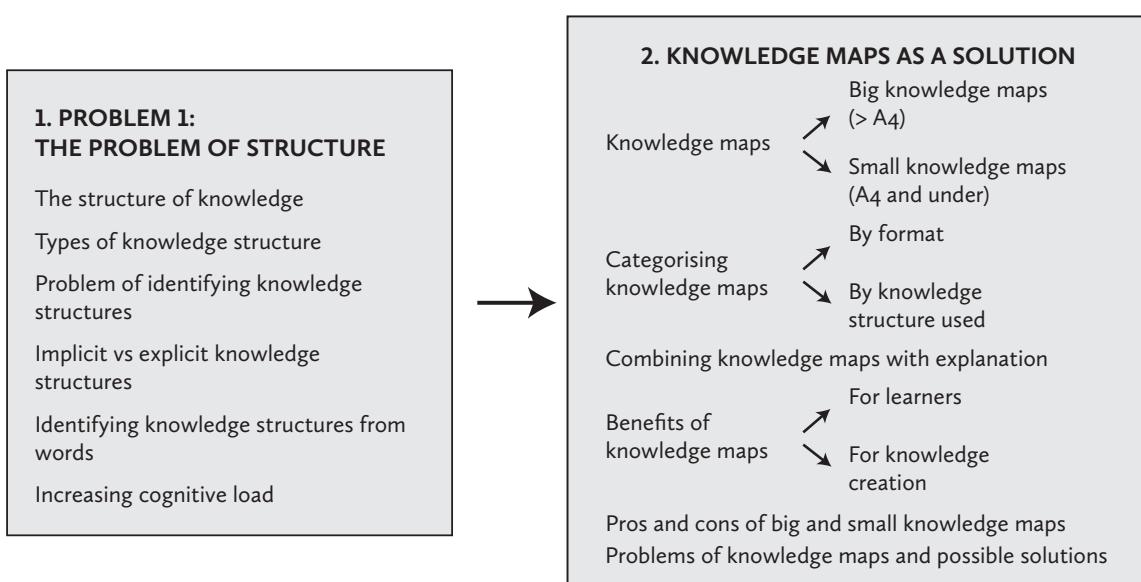
13. The benefits of multi-level content include:

- allowing an at-a-glance understanding of the knowledge structure or structures being used
- making it easier for learners to move between the different levels of knowledge
- allowing learners to easily choose the particular knowledge level or levels that best meet their needs.

14. Areas where multi-level content could prove particularly useful include:

- non-fiction books
- businesses and organisations
- education
- maps of particular knowledge areas
- training courses.

PART 1 SUMMARY: THE PROBLEM OF STRUCTURE



Content map

1. Problem 1: The problem of structure

All knowledge has structure. Each description, concept, idea or argument is made up of different knowledge elements which are deliberately structured by the speaker or writer in a way that will best express the meaning that they want to communicate.

Making sense of any knowledge requires an understanding of how the explanation is structured.

Knowledge structures

There are many different ways to structure knowledge. The different types of knowledge structure include:

| | |
|---------------|--------------------|
| Taxonomy | Causal explanation |
| Timeline | Argument/case |
| Story | Content structure |
| Description | Process/sequence |
| Relationships | |

Deciphering knowledge structures

Learners have to translate linear text or spoken words into knowledge structures, which can prove difficult in the absence of descriptions of these structures.

There is a hypothetical example of a non-fiction book in the main text which shows how there are core and subsidiary knowledge structures buried in the linear page structure, which need to be deciphered by the reader.

Implicit vs explicit knowledge structures

Knowledge structures can be:

- 1) implicit only with no explicit description, either visually or through words
- 2) described explicitly through spoken words or text
- 3) described explicitly through visuals.

Example of a written description

See the example of the Lasagna Project in the main text. It shows that, even when a knowledge structure is explicitly described in words, it is still much harder to understand than when the structure is shown visually.

Increasing cognitive load

Explanations that don't provide visual descriptions of knowledge structures increase extraneous cognitive load, which causes friction and slows down the rate of learning.

This leaves less cognitive energy available for the important tasks of understanding, assessment and reflection.

2. Knowledge maps as a solution

One potential solution to the problem of understanding knowledge structures is to provide explicit visual descriptions of structures using knowledge maps in combination with a more detailed written or spoken explanation.

Knowledge maps may be defined as explicit visual depictions of knowledge structures showing:

- the different elements of a field or topic
- the relationship of these elements to each other.

Knowledge maps consist of a combination of:

- diagrams and tables, representational graphics or a combination of both
- category names or category names with descriptions.

They can come in many different sizes from small to very large.

PART 1 SUMMARY: THE PROBLEM OF STRUCTURE

Examples of big knowledge maps

Size: greater than A4



Mega Trends and Technologies map
A map of future technology trends



Big History Timeline Wallbook
A map of history from the Big Bang to the present day



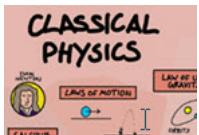
Cognitive Bias Codex
A categorisation of cognitive biases



Linguisticator language maps
A comprehensive description of every single aspect of a particular language

Examples of small knowledge maps

Size: A4 or smaller



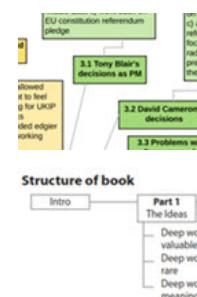
Map of physics
A map showing the different areas of physics



The rise of Hitler
A map explaining the factors behind the rise of Hitler



Literary periods in English literature
A timeline showing some different literary periods



All Out War

A visual summary of Tim Shipman's book

Deep Work

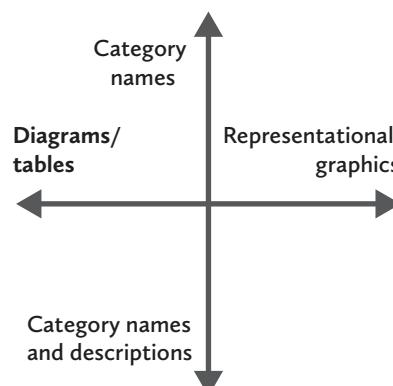
A visual summary of Cal Newport's book

Categorising knowledge maps

There are two ways to categorise knowledge maps.

BY FORMAT

Each knowledge map can be categorised on the basis of their use of graphics and the use of category names or category names with descriptions.



BY KNOWLEDGE STRUCTURE USED

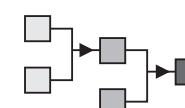
Knowledge maps can use any of the different types of knowledge structure:

| | |
|---------------|--------------------|
| Taxonomy | Causal explanation |
| Timeline | Argument/case |
| Story | Content structure |
| Description | Process/sequence |
| Relationships | |

Combining knowledge maps with explanation

Knowledge maps are summaries so they generally require further explanatory detail to be useful. Explanations can be either written or spoken, and can be short or long.

KNOWLEDGE MAP + EXPLANATION



Written

Book
Article/paper
Web page
Blog post

Spoken

Talk/lecture
Classroom explanation
YouTube video
Presentation

Big vs small knowledge maps

Big knowledge maps work when there is a large amount of information that needs to be presented. Part of the impact that big maps have comes from the fact that their size conveys the extent of a subject area.

In addition, they allow large amounts of information to be presented in one place so that all the connections between the different elements can be seen together.

However their sheer size can be overwhelming to learners and can also require significant resources to produce.

Smaller knowledge maps can be easier and quicker to produce, and work well for more constrained areas of knowledge. However they cannot include the amount of detail that can be fitted on to big knowledge maps.

PART 1 SUMMARY: THE PROBLEM OF STRUCTURE

Benefits of knowledge maps

BENEFITS FOR LEARNERS

Knowledge maps can:

- show large amounts of knowledge
- display complex relationships between elements, which would be confusing to explain using just text or spoken words
- help learners see new connections between ideas, concepts and/or facts
- help to simplify a subject area because maps can only include the most critical information
- help to reduce information overload by putting ideas in their context
- help to make knowledge more accessible as the big picture viewpoint of maps allows an initial scan to give a quick grasp of the material
- make knowledge more concrete and therefore help to make it more inviting and interesting.

BENEFITS FOR KNOWLEDGE CREATION

The process of making knowledge maps isn't just about creating visual representations or frameworks of existing knowledge ie. mapping what is already known.

It can also stimulate the creation of new knowledge by:

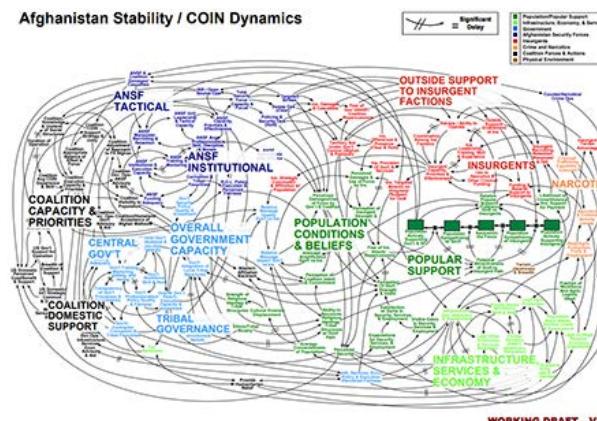
- identifying gaps and new patterns as Aaron Ralby has found with the development of the Linguisticator language maps. As he writes:

“By mapping, order emerges from apparent chaos – an order that was there all along, but impossible to see without the map.”

- helping to develop new categories and frameworks as occurred with the Cognitive Bias Codex. Buster Benson's re-categorising of the biases allows people to understand the different purposes and types of cognitive bias in a more usable and in-depth way.

Problems

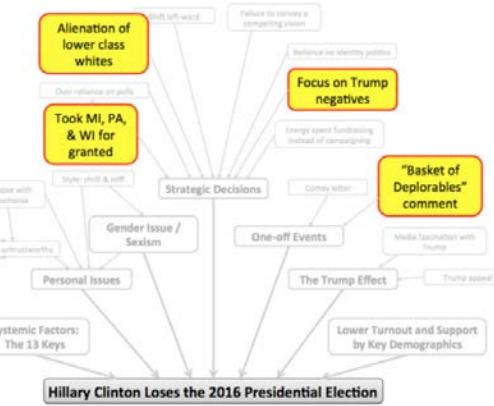
Knowledge maps fail when too much detail is included and readers end up feeling overwhelmed. This occurred with the infamous causal loop diagram that analysed the US's counter-insurgency strategy in Afghanistan in 2009 and which was widely criticised for its excessive complexity.



One potential solution to the problem of excess detail has been suggested by psychologist Gary Klein.

He understands the need to include multiple causes so as not to oversimplify an explanation.

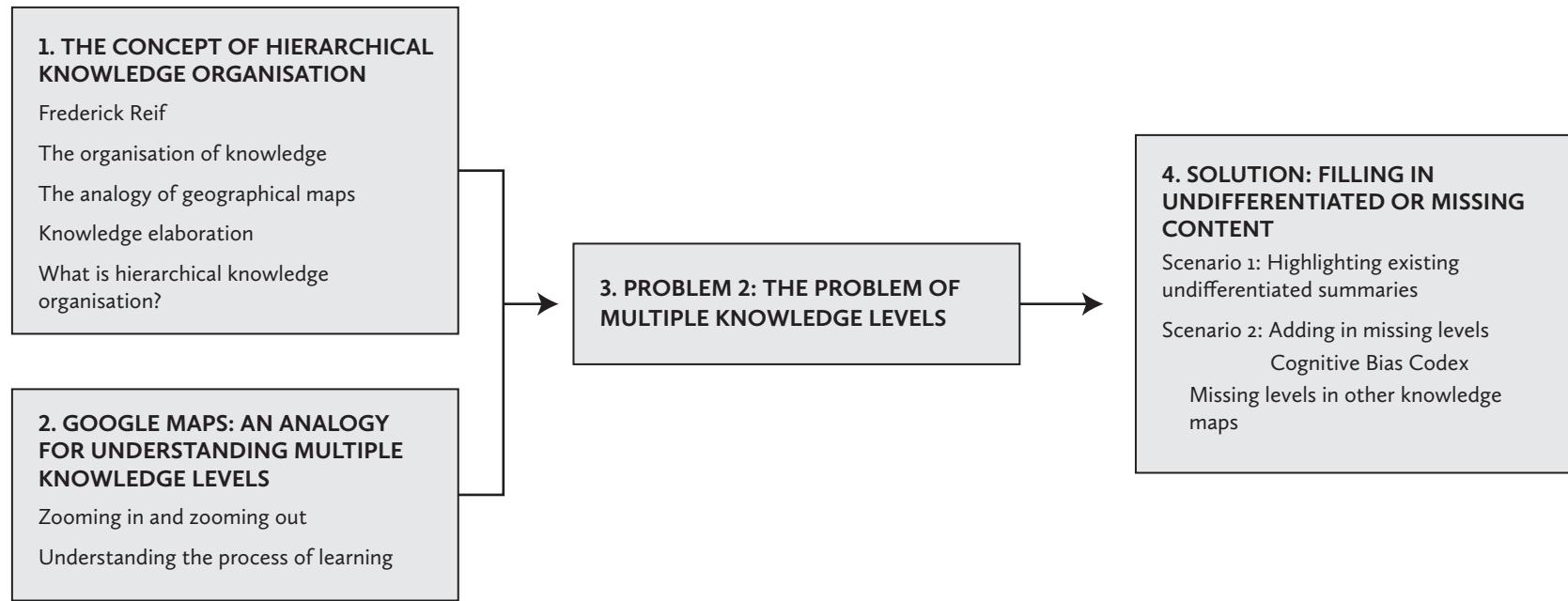
However he also understands that not all causes have the same impact and that it is important to differentiate the most impactful causes from less important ones, as he has done with his explanation of the reasons for Hillary Clinton losing the 2016 US Presidential Election.



Source: Gary Klein

Another solution is to create multiple knowledge maps which show different levels of detail. I will be discussing these in Part 2.

PART 2 SUMMARY: THE PROBLEM OF MULTIPLE KNOWLEDGE LEVELS



1. The concept of hierarchical knowledge organisation

The concept of hierarchical knowledge organisation was developed by Frederick Reif, a physicist who also published work in the field of cognitive science and education.

Key question

Reif was interested in how to help humans cope with large amounts of knowledge and concluded that the solution was to make sure that knowledge was organised effectively. He believed that it was as important to focus on the organisation of knowledge as it was on the content.

The analogy of geographical maps

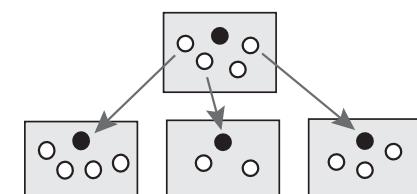
He thought that maps provided the best analogy for organising information. They allow huge amounts of geographical detail to be organised and findable by providing information at different scales. Depending on one's needs, one can choose to see a map at varying levels of detail from the world as a whole all the way down to maps of individual roads and groups of houses.

Knowledge elaboration

Reif felt that the same process can be applied to knowledge. A topic or an argument can be explained or elaborated over different levels.

The elaboration can go from:

- the big picture to the detail
- important knowledge to subsidiary knowledge
- the whole to constituent parts
- general information to specific information
- the wider context to a narrower focus.



PART 2 SUMMARY: THE PROBLEM OF MULTIPLE KNOWLEDGE LEVELS

2. Google Maps: An analogy for understanding multiple knowledge levels

Google Maps allows users the choice of either zooming out to get a wider view or zooming in to get a more detailed view so that they can find just the right level of detail for their needs. They can also move across the map at each level of detail to look at both adjacent and distant areas.

The ability to zoom in for more detail, zoom out for the bigger picture or to move sideways is exactly what one needs to be able to do when learning a subject or reading a book.

3. Problem 2: The problem of multiple knowledge levels

The concept of hierarchical knowledge organisation suggests that all but the most simple explanations require multiple knowledge levels organised by detail and importance in order to be understandable.

The top levels of an explanation provide the big picture summary that draws together the threads of an argument or description.

They can also outline the more important elements of the explanation. The lower levels in the hierarchical structure provide the essential detail and subsidiary information.

Learners can struggle if:

- descriptions of the big picture or the core information are not marked out clearly but are instead hidden in a mass of detail or
- descriptions of the big picture or the core information are lacking and there is excessive focus on detail.

Different people also have different needs. Some may only require the big picture summary or an outline of the most critical elements. Others will require more detail or subsidiary information.

A lack of clearly differentiated knowledge levels adds more cognitive friction as people struggle to find the appropriate knowledge level or levels for their needs.

4. Solution: Filling in undifferentiated or missing content

There are two different scenarios that relate to multiple knowledge levels.

Scenario 1: Undifferentiated summaries

The first scenario occurs when the summaries of the different levels already exist but they are distributed throughout a text or speech with little indication that they are providing an overview or core information. The solution is to create differentiation by highlighting these parts.

Scenario 2: Missing content

The second scenario occurs when whole knowledge levels or summaries of individual topics have been missed out. The solution is to add in summaries of the missing topics or sub-topics.

COGNITIVE BIAS CODEX

The Cognitive Bias Codex is a good example of missing content. Buster Benson started with an article categorising the 189 cognitive biases into four different problem areas and 20 cognitive bias categories.

Concerned that the original article was too long (and possibly too complex), Benson wrote what he called a simplified cheat sheet four months later. This can be seen as zooming out to create a new higher knowledge level.

However, there is also potentially a missing level below the original map as some people might want more detail on the individual cognitive biases.

MISSING LEVELS IN OTHER KNOWLEDGE MAPS

We can also look at some of the other knowledge maps in terms of potentially missing levels.

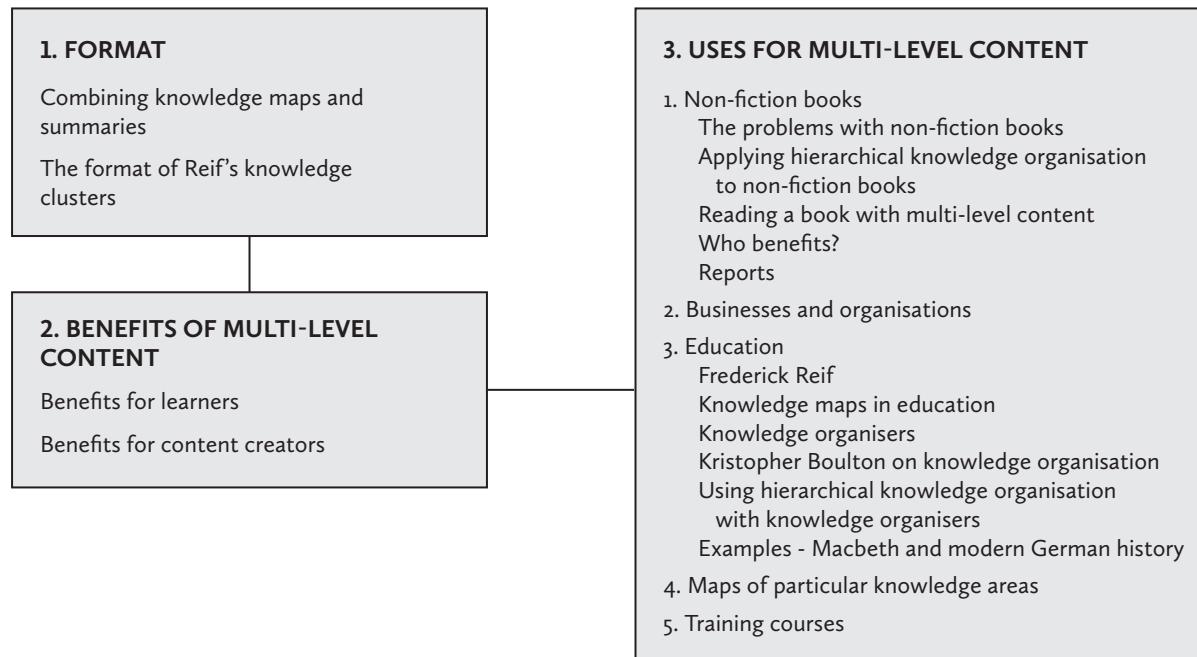
Both the Big History Timeline Wallbook and Richard Watson's Megatrends and Technologies map include an incredible amount of detail, which some readers will find overwhelming.

Therefore it could be helpful to also provide a higher summary level which would allow readers to zoom out to focus on the bigger picture changes or trends.

Dominic Walliman's Map of Physics is a top-level description of the individual fields within physics so, on the next level of detail down, there could be individual knowledge maps for each of these fields.

The two book summaries I included in Part 1 - *All Out War* by Tim Shipman and *Deep Work* by Cal Newport - could be augmented by knowledge maps and summary explanations of all the individual chapters as well.

PART 3 SUMMARY: MULTI-LEVEL CONTENT: FORMAT, BENEFITS AND USES



1. Format of multi-level content

The existence of multiple knowledge levels discussed in Part 2 make understanding the structure of an explanation even harder to understand.

Instead of needing to understand the relationships between elements just on one level, the existence of multiple levels means there is now a need to understand relationships between levels as well as within levels.

This makes visual representations of knowledge structures even more essential. So, I believe that

multi-level content needs to combine knowledge maps showing the relationship of elements to each other with explanatory summaries.

The Cognitive Bias Codex example showed how the combination of knowledge maps and summaries made the explanations much easier to understand.

That means we can re-state Reif's diagram of a hierarchically clustered knowledge organisation by showing each cluster with both elements as shown in the next column.



2. Benefits of multi-level content

Multi-level content provides benefits both for learners and content creators.

Benefits for learners

These are some of the benefits of organising knowledge hierarchically through multi-level content:

- they help learners to grasp the big picture of an area quickly and then allow them to move quickly between the big picture and the detail
- they allow learners to identify quickly the most critical information in an area without the danger of being overwhelmed by detail
- being able to quickly scan the key ideas of an area allows learners to easily decide whether that area is worth more of their time and whether they want to dig more into the detail
- making knowledge structures over multiple levels explicit means that learners are given clarity about the components of a topic, description or argument and how they fit together.
- multi-level content can enhance memorisation because easily accessible summaries make it easier to revise and embed ideas
- being provided with a coherent and understandable description of a topic or curriculum allows learners to assess how much progress they have made in a particular area and how much more knowledge they have to cover.

PART 3 SUMMARY: MULTI-LEVEL CONTENT: FORMAT, BENEFITS AND USES

Benefits for content creators

There are two main benefits for content creators.

1. The concept of multi-level content provides strategies to help content creators communicate more effectively so they can get their messages across with clarity and in an easier-to-understand format.
2. The process of multi-level content helps to improve one's thinking process. Creating knowledge maps forces one to clarify the relationships between all the knowledge elements. Creating summaries of the different components helps to refine the quality of one's argument or description. Doing both helps to identify gaps and any extra work that is needed.

3. Uses for multi-level content

There are five particular areas in which multi-level content could be used.

- 1) Non-fiction books
- 2) Business/organisations
- 3) Education
- 4) Training courses
- 5) Maps of particular knowledge areas

3.1 Non-fiction books

Strategies have been developed to help people to read non-fiction books more effectively, such as how to identify and extract the most important ideas from a book.

However what would be much more effective is if non-fiction authors were to produce multiple level content with knowledge maps and hierarchically organised content.

Some problems that non-fiction readers have

Here are some of the problems that readers report about reading non-fiction books:

- finding it hard to get started
- losing interest and momentum early on
- lacking a big picture
- being overwhelmed by too much detail
- losing the thread after a break from a book
- forgetting a book's ideas
- struggling to work out what action to take
- what to do on returning to an already read book.

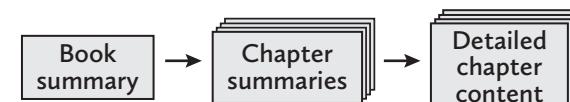
Applying MLC to non-fiction books

Most non-fiction books will have three levels of detail:

- a big picture level for the ideas in the book as a whole
- a big picture level for the ideas in each individual chapter
- the detailed content in each individual chapter.

If we wanted to provide multi-level content that differentiated the content in each of these levels, we could have:

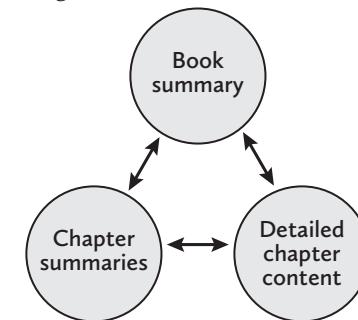
- a book summary with a knowledge map and explanatory text for the book as a whole
- chapter summaries with knowledge maps and explanatory text for each individual chapter
- the contents of individual chapters with text combined with diagrams, tables and representational graphics.



Multi-level content isn't appropriate for non-fiction books that have a strong narrative component and where knowing the big picture before starting a detailed read would ruin the surprise of the ending.

Reading a book with multi-level content

Instead of mainly reading from start to finish, multi-level content allows readers to move between the book summary, the chapter summaries and the chapter detail according to their needs.



Who benefits?

I. READERS

This is how multi-level content can help with the previously-identified problems about reading non-fiction books:

- *finding it hard to get started* - the 20 minutes or so needed to read the book and chapter summaries provides an easy way in to starting a book
- *losing interest and momentum early on* - the summaries allow readers to be much clearer about whether the book is going to be worth reading in full and to quickly identify which chapters of the book they are going to find most interesting
- *lacking a big picture* - multi-level content gives readers the flexibility to switch between detail and context
- *being overwhelmed by too much detail* - multi-level content allows readers to focus on the level of detail they find most helpful

PART 3 SUMMARY: MULTI-LEVEL CONTENT: FORMAT, BENEFITS AND USES

- *losing the thread after a break from a book* - multi-level content allows readers to quickly refresh their memories about what they have previously read
- *forgetting a book's ideas* - multi-level content allows readers to easily engage in retrieval practice
- *struggling to work out what action to take* - adequate summaries allow readers to easily revisit the recommended strategies and behaviours
- *what to do on returning to an already read book* - summaries allow readers to get an overview of a whole book again in about 20 minutes.

2. AUTHORS

The benefits of multi-level content for readers should make any non-fiction authors who want to communicate their ideas effectively keen to investigate the concept.

Reports

Multi-level content could be also valuable for reports so readers aren't faced with text-heavy content with an opaque structure.

3.2 Businesses and organisations

There are different ways that businesses and organisations could use multi-level content:

- developing their own megatrends map similar to Richard Watson's map focusing on changes that may be coming to their own industry or field to use for discussion and creative thinking
- using maps and explanations to explain current strategies to staff and to provide an easily understood framework within which ongoing decisions can be made.
- using a map to explain the strategies or activities of a company or organisation to external groups.

3.3 Education

I'm not involved in the education field so the following ideas are put forward tentatively.

Frederick Reif

Reif is passionate about the importance of organising knowledge in education As he writes:

“As much attention must be paid to the organization of knowledge as to its content. When trying to convey a body of knowledge, teachers should attempt to develop explicitness, and then gradually expand, a well-organized knowledge structure that students can actively use.”

Knowledge maps in education

Many of the knowledge maps discussed in Part I show that an increasing number of educators understand the importance of organising knowledge in a visual way.

These included the Big History Timeline Wallbook, the Linguisticator language maps and the Map of Physics.

Knowledge organisers

Recently there has been a growth of interest in knowledge organisers, which list essential facts, concepts, definitions etc that need to be memorised.

In tandem, there has been concern that focusing on single items of knowledge doesn't help pupils to understand the relationships between them.

Kristopher Boulton has suggested that adding a visual element to knowledge organisers might help pupils to understand relationships better as well as help to anchor items in memory more effectively.

Examples

I provide two examples showing how hierarchical knowledge organisation might be incorporated:

- Shakespeare's play *Macbeth*
- Modern German history

Macbeth

In the main text, I give an example of what a very simple knowledge organiser for Macbeth might look like, incorporating both knowledge maps and explanation.

Modern German history

With the modern German history example, I show how pupils can be helped to navigate different knowledge levels so they can move easily between the big picture and the detail, and understand how specific events fit in to the wider context.

3.4 Maps of particular knowledge areas

I think hierarchically organised knowledge maps and summary explanations could prove particularly useful for people exploring new knowledge areas.

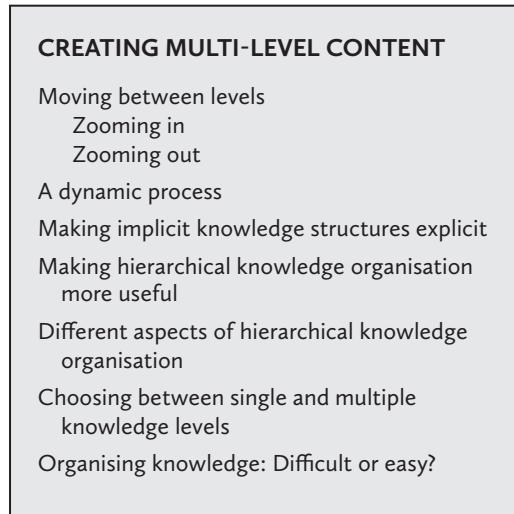
Being able to see the big picture and then to drill down into more of the detail is what lots of people would find helpful when learning about a new area.

3.5 Training courses

Very few online courses seem to have to know how to use hierarchical knowledge organisation to help learners learn more effectively. Some of the problems include:

- a lack of knowledge maps showing the structure of the training so learners can work out at all times where they are in the training process
- a lack of summaries at different levels of detail so that learners find it difficult to review key points when they are going through the course or reviewing their knowledge after they have finished it
- an inability to differentiate between important information and subsidiary information so that all information is presented together on one level and learners have to go through, say, a 4 or 5 hour course and then extract for themselves what is important.

PART 4 SUMMARY: CREATING MULTI-LEVEL CONTENT

*Content map*

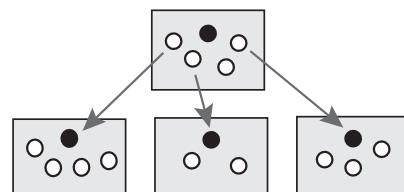
4.1 Moving between levels

There are two main processes used for creating multi-level content:

- zooming in
- zooming out.

Zooming in

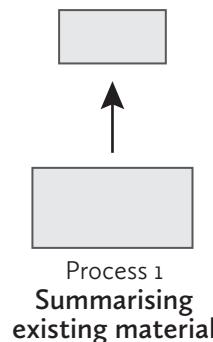
The process of zooming in involves working out the multiple levels of sub-topics and detail which are needed for explaining a topic or for making an argument.



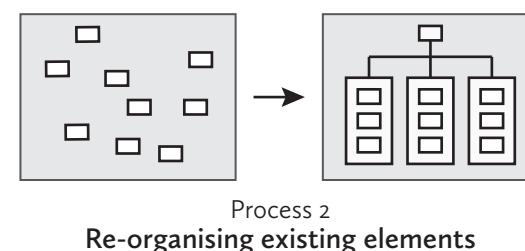
Zooming out

The aim of zooming out is to arrive at a summarised or a new big picture. It is a more complicated operation than zooming in as there are three different processes that can be used:

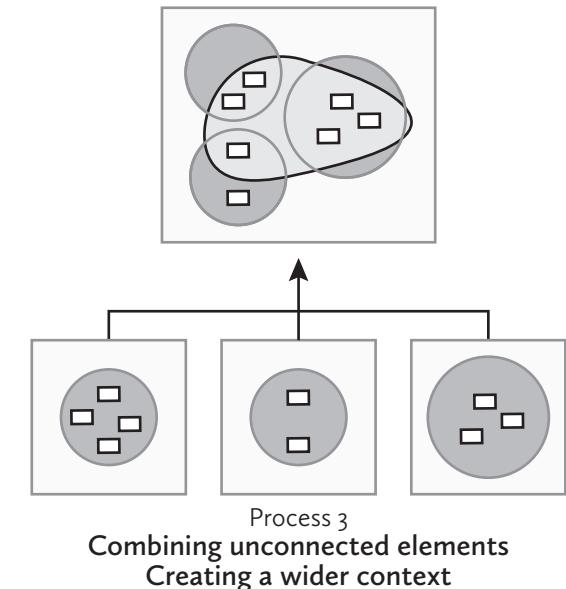
1. **Summarising existing material.** This process is about taking existing material and summarising the key elements of it.



2. **Re-organising existing elements.** This process starts with existing knowledge elements and looks to see how they can be re-organised to produce additional or new meaning.



3. **Combining new elements or creating a wider context.** This process is about creating new meaning by combining unconnected knowledge elements or by putting existing knowledge elements into a new context.



The key processes involved in zooming out can include one or more of the following:

- generalising
- summarising
- categorising
- contextualising
- systematising
- comparing
- simplifying
- structuring
- connecting
- ranking
- filtering.

PART 4 SUMMARY: CREATING MULTI-LEVEL CONTENT

4.2 A dynamic process

At the beginning it's often clear which process one needs to start with. If there is a clear, circumscribed topic that just needs to be broken into more detail, then one starts with zooming in.

However, if one starts with only a hazy idea about how some knowledge elements are going to be organised or what context they are going to be put in, then zooming out will be the process to use.

However, soon after starting, it may well become a more dynamic process as one moves between structure (ie. what the knowledge elements are and how they are connected) and explanation, and up and down levels of both of them.

4.3 Making implicit structures explicit

There is another way of organising knowledge, which is to start with some existing text or a spoken explanation and make the implicit knowledge structures within them explicit.

This involves:

- identifying the overarching knowledge structure and the subsidiary structures used
- working out how all the knowledge structures connect to each other
- deciding on the number of knowledge levels that work best for the explanation
- creating new knowledge maps where needed
- identifying the big picture summaries needed for the different levels and then either extracting existing text or creating new text.

4.4 Making hierarchical knowledge organisation more useful

Frederick Reif provided four tips to increase usability:

- 1) making sure that knowledge clusters aren't too big or too small
- 2) choosing the right knowledge structure for each cluster
- 3) creating overlapping clusters so people can move easily from one to another
- 4) cross-referencing related knowledge that isn't in a hierarchical relationship.

4.5 Different aspects of hierarchical knowledge organisation

There are a number of key aspects involved in understanding the relationship between knowledge levels. They include moving:

- between the big picture and the detail
- between important knowledge and subsidiary knowledge
- between the whole and the parts
- between general knowledge and specific knowledge
- between a wider context and a narrower focus.

It can be helpful to ask a set of structured questions to check whether all the different aspects have been covered.

4.6 Choosing between single and multiple knowledge levels

Choosing between having a single knowledge level or multiple ones will depend on the complexity and depth of a topic or argument - as well as how much detail needs to be communicated.

4.7 Organising knowledge: Difficult or easy?

Many people might struggle to create knowledge maps similar to some of the more detailed ones discussed in Part 1, which will require:

- a reservoir of knowledge
- patience and creativity in identifying themes and patterns that will usefully connect different knowledge elements
- a commitment to structuring knowledge in ways that will be interesting and informative to learners.

However a knowledge map doesn't need to have a sophisticated design or to be intended for public consumption.

Creating a knowledge map can be as simple as writing the names of a few categories or facts on a piece of paper and then working out what lines to draw to connect them most effectively.

The benefits come from the thought and understanding required to connect different knowledge elements together and how the map actually looks is of little importance.

PART 1 - THE PROBLEM OF STRUCTURE

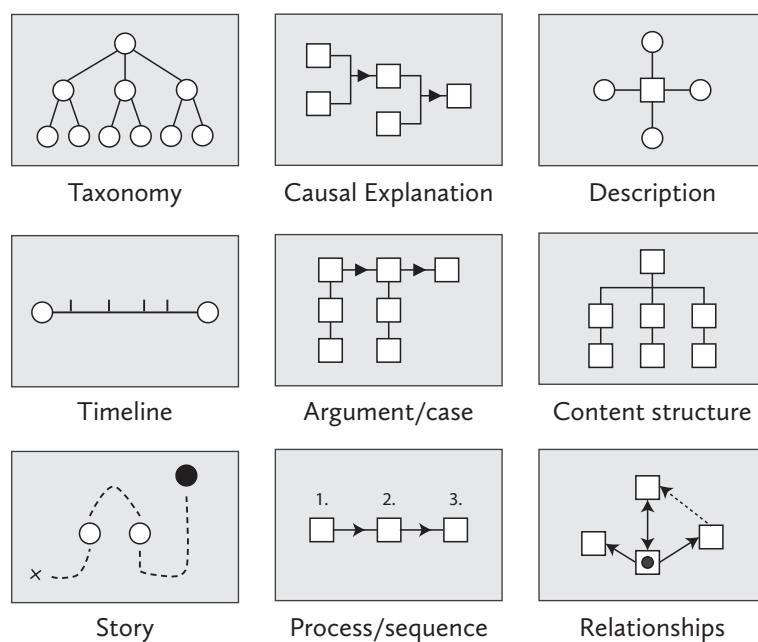
1.1 Problem 1: The Problem of Structure

1.1.1 THE STRUCTURE OF KNOWLEDGE

When talking about the structure of knowledge, I use the following definition of structure from the Oxford Dictionary: “the arrangement of and relations between the parts or elements of something complex”.

So by saying that “all knowledge has structure”, I mean the following: that each description, concept, idea or argument is made up of different knowledge elements which are deliberately structured by the speaker or writer in a way that will best express the meaning that they want to communicate.

1.1.2 TYPES OF KNOWLEDGE STRUCTURE



There are many different ways in which knowledge can be structured. Here are some examples:

- **taxonomy/family tree** - a classification of elements relating to a particular topic or area, often shown in a hierarchical format
- **causal explanation** - an explanation of the causes that lead to a particular result
- **description** - an explanation of the parts that make up a particular whole
- **timeline** - a listing of events or trends shown in order of occurrence
- **making an argument/case** - an explanation of the reasoning that leads to a particular conclusion
- **content structure** – a depiction of how a piece of content (like a book or presentation) is structured
- **story** – an account of events and experiences that occur in the progression from a starting point to an ending point
- **process/sequence** - a description of the steps involved in a particular process, procedure or sequence
- **relationships** - a description of how a group of elements relate to each other, which can include comparisons.

Each explanation can comprise a collection of different knowledge structures and some of these may be nested. To give one example of nesting, a description of different elements may also include stories about each element.

(This isn't an exhaustive list of knowledge structures. Please let me know via my Contact Form if there are others you think I have missed out.)

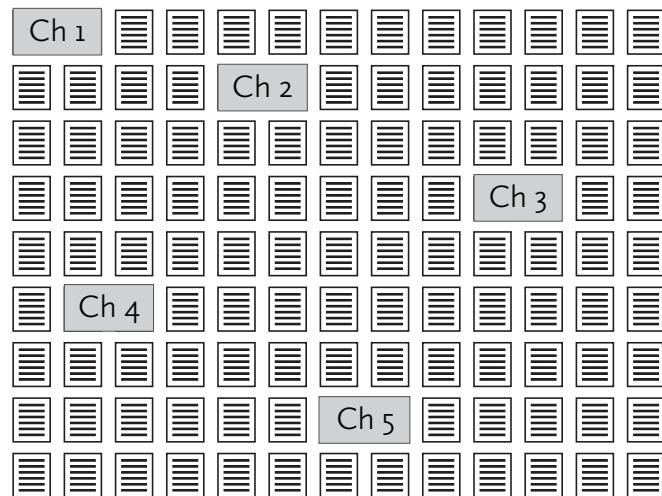
1.1.3 THE PROBLEM OF IDENTIFYING KNOWLEDGE STRUCTURES

In order to extract the meaning from an explanation, readers and listeners have to understand the knowledge structures being used. This can be difficult when they are forced to rely solely on the sequential building blocks of written text or spoken words.

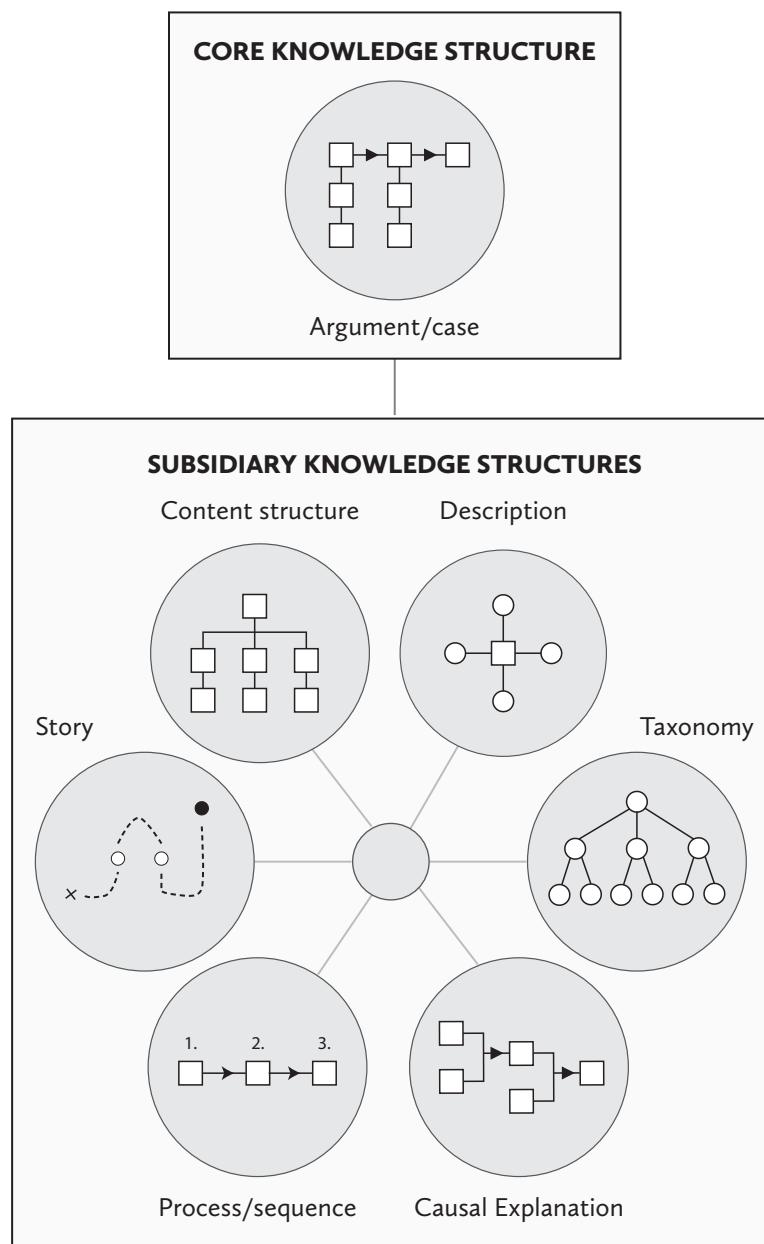
Take the hypothetical example of a non-fiction business book which is arguing for the benefits of a new business strategy and which mainly relies on text with few visuals.

Readers have to decode the linear structure of the book's pages to identify all the different knowledge structures being used.

They will have to go from this:



to this:



The book will have an overall knowledge structure which presents the main argument ie. the benefits of using that particular business strategy.

However, in order to make that case, there will also be other subsidiary knowledge structures nested within the overall knowledge structure. These could include:

- an explanation of the content structure, describing the contents of the book and how the different chapters relate to each other
- a description of the different elements of the business strategy
- a taxonomy of different business strategies over the years with an explanation of where this new strategy fits in
- a causal explanation describing the rationale for using the strategy
- a process breakdown showing the steps needed to implement the strategy
- stories about people who have used the strategy effectively.

1.1.4 IMPLICIT VS EXPLICIT KNOWLEDGE STRUCTURES

There are three different ways in which knowledge structures can exist within descriptions of knowledge:

1. the structure exists implicitly but isn't described explicitly
2. through explicit verbal or textual description
3. through explicit visual description.

Because structure is inherently spatial, being provided with only an implicit knowledge structure means that a great deal of cognitive energy has to be taken up in converting text or spoken words to spatial structures of meaning.

However, even if knowledge structures are described explicitly with words, many people will still face comprehension problems, as the following example shows.

1.1.5 IDENTIFYING KNOWLEDGE STRUCTURES FROM WORDS

In his book *The Napkin Sketch Workbook*¹, Don Moyer has provided a powerful example of how hard it can be to extract meaning even with the benefit of a knowledge structure explicitly described in words.

Moyer gives the following description of the relationships of staff in a company.

"Jeff is the President of the company. Sue is the head of the Design team. Erin, Ted, and Ian work for Sue. José is the head of Marketing. June, Jill, and Carlton report to José. Sue, Ted, Ian, and June are working on the Lasagna Project."

Then he asks the following questions.

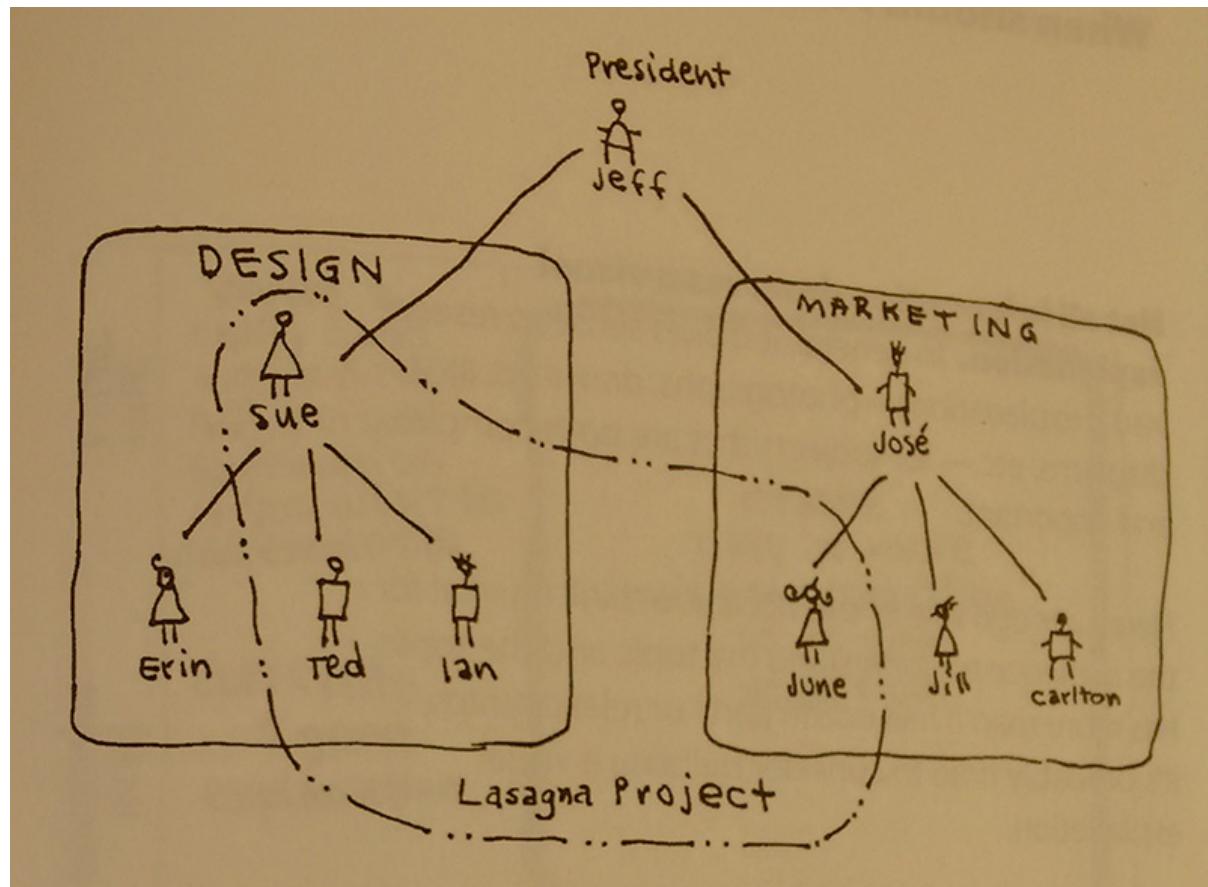
1. Who's the highest ranking staff member working on the Lasagna Project?
2. Which department has the most staff members working on the project?
3. Which staff members are not involved with the Lasagna Project?

Take a minute to answer them.

¹ Available from www.blurb.co.uk/b/1892410-napkin-sketch-workbook or www.blurb.com/b/1892410-napkin-sketch-workbook.

If you're anything like me, you will have found those questions required a good deal of effort to answer.

But now have a look at Don Moyer's diagram of the relationships and then try answering the questions again.



1. Who's the highest ranking staff member working on the Lasagna Project?
2. Which department has the most staff members working on the project?
3. Which staff members are not involved with the Lasagna Project?

This time, I'm sure you found that the questions needed much less effort.

Knowledge structures are much easier to understand when they are presented visually rather than explained in words.

It can be hard mental work to construct relationships of position and importance from spoken or written descriptions of knowledge structures. In contrast, a diagram allows one to easily read the relationships off the page in seconds.

1.1.6 INCREASING COGNITIVE LOAD

It's not the case that implicit knowledge structures or those just described in words are too difficult for most people to understand. The key question however is whether it is the best use of their time or energy.

Cognitive load theory, initially developed by Professor John Sweller, refers to the cognitive demands placed on learners. Due to the limitations of working memory, learners find it difficult when excessive cognitive demands are placed on them. So the greater the cognitive load, the more learners are going to struggle with learning.

One of the critical issues in learning, therefore, is to reduce the unnecessary cognitive load imposed on learners as much as possible.

As Sweller and his colleagues write:

“One aim of instructional design is to reduce extraneous cognitive load so that a greater percentage of the pool of working memory resources can be devoted to issues germane to learning rather than issues extraneous to learning.”²

It is my contention that explanations that don't also provide a visual description of knowledge structures increase extraneous cognitive load.

Learners should be spending their valuable cognitive energy understanding concepts, assessing the truth and usefulness of the argument being made, and reflecting on how the writer's or speaker's ideas integrate with or challenge their existing ideas.

When cognitive energy is taken up trying to decode knowledge structures that are not expressed visually, less energy is available for the critically important tasks of understanding, assessment and reflection.

² From *Cognitive Load Theory* by John Sweller, Paul Ayres and Slava Kalyuga (Springer, 2011). Cited in [Oliver Caviglioli's sketchnote](#) of Chapter 5 of the book.

1.2 Knowledge maps as a solution

A solution to the problem of understanding knowledge structures is to provide explicit visual descriptions of structures using knowledge maps in combination with a more detailed explanation.

I define knowledge maps as visual descriptions which show:

- i) the different elements of a field or topic and
- ii) the relationship of the elements to each other.

This is my personal definition. The term is used by others to mean something different. They can also be called content maps or structure maps.

Knowledge maps combine two aspects:

- visually they can consist of:
 - abstract graphics (eg. diagrams, flowcharts etc) and tables
 - representational graphics
 - or a combination of the two
- in terms of text, they can include
 - just category names
 - or category names with additional descriptions.

The components of knowledge maps can include ideas, concepts, categories and facts.

I will start by giving some examples of knowledge maps in both larger and smaller format. I will then examine some of the different aspects of knowledge maps.

It is important to realise that none of the maps stand on their own. Each of them are accompanied by explanations in books, videos, articles, courses or classroom teaching, as I will go on to discuss later.

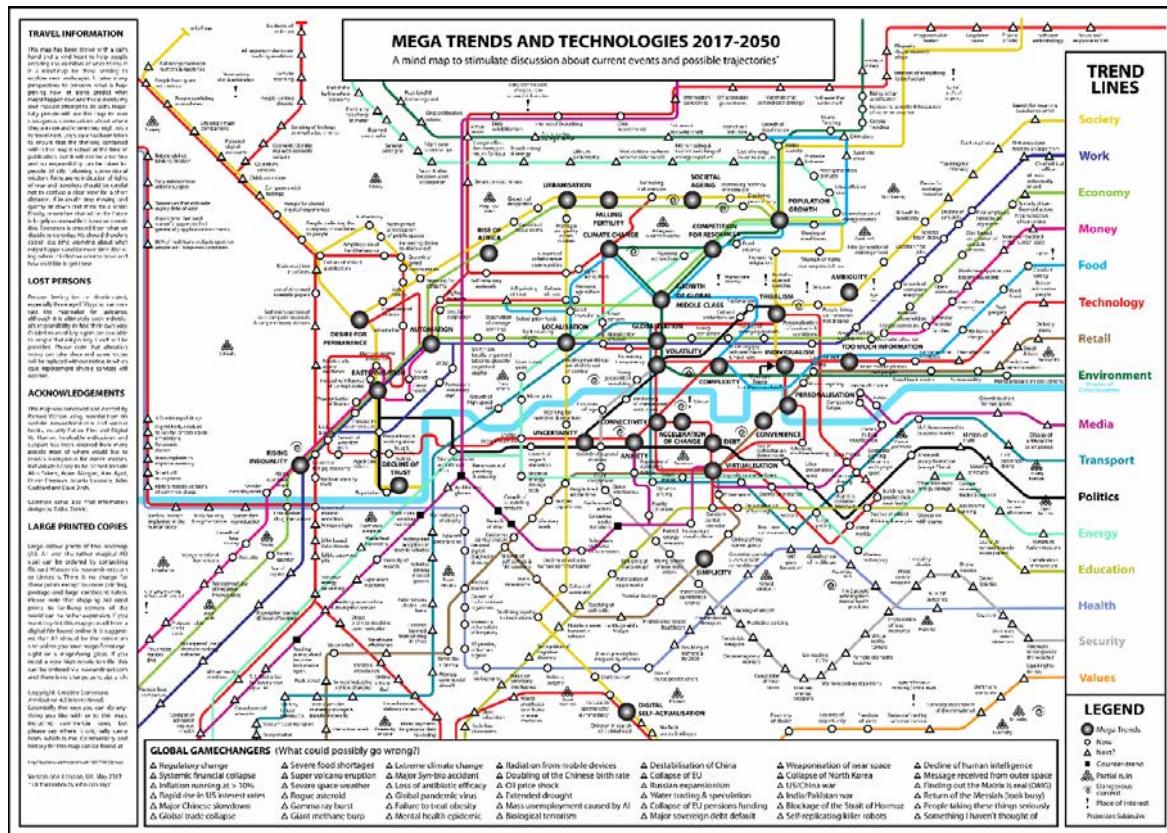
1.2.1 BIG KNOWLEDGE MAPS

I define big knowledge maps as maps greater than A4 size.

I have included examples of four here:

- the Mega Trends and Technologies map, which looks at future trends and technologies
- the Big History Timeline Wallbook, which provides a map of history from the Big Bang all the way up to the present day
- the Cognitive Bias Codex, which is a categorisation of cognitive biases
- Linguisticator language maps, which aim to provide a comprehensive description of every single aspect of individual languages.

i) Mega Trends and Technologies map



From [https://nowandnext.com/PDF/Mega Trends and Technologies 2017-2050 \(Web\).png](https://nowandnext.com/PDF/Mega%20Trends%20and%20Technologies%202017-2050%20(Web).png)

Futurist Richard Watson has created a [big knowledge map of future trends and technologies](#) up to 2050. It needs to be large because of the huge quantity of information Watson has included on it. One of the versions it's available in is Ao, which is sixteen times the size of an A4 sheet.

The aim is to stimulate discussion about potential trajectories to the future. As he writes in the map description:

“Remember that while the future is largely unknowable it is not uninventible. Tomorrow is created from what we decide to do today. We should therefore spend less time worrying about what might happen and far more time discussing where it is that we want to travel and how we'd like to get there.”

The map came about because of Watson's frustrations with the limitations of text. As Watson explained in [an interview with Adam Morgan](#):

“I was writing a bunch of megatrends as a word document and it was just boring and useless because you couldn't connect anything. It didn't seem to come alive”.

So he took his children's felt pens out and started to “join things together” and to “play around with the connections”.

In the interview, he went on to say:

“Information overload means that a summary of what’s going on is very attractive to people..... We’re moving into a much more visual culture now so that resonates. [The map] looks vaguely attractive aesthetically so that resonates as well.”

It took Watson about two years to complete the map and involved drawing about 22 versions by hand.

Here are some of the key aspects of the map:

- it's loosely based on the London Underground map with the key themes (eg. society, work, money, environment, health, security and values) appearing as the underground lines
- the map starts in the centre using the current period (roughly 2017-2020) and the future radiates outwards
- there are 31 megatrends (including population growth, the rise of Africa, climate change, societal ageing, growth of the global middle class, tribalism, the acceleration of change, the decline of trust and anxiety)
- there are current trends ('now') and future trends that appear on the underground lines linked to particular themes
- there are counter-trends that go in the opposite direction to the dominant trends - eg. renaissance of painting and drawing, rebirth of vinyl, growth of storytelling festivals. Interestingly, they seem only to appear in the media theme
- there are partial ruins, which he defines as categories that are becoming less common - eg. privacy, peripheral vision, patience, generosity of spirit, humility, coral reefs
- there are dangerous currents, where perils await eg. rising inequality, tribalism, societal ageing and debt
- there are places of interest eg. the changing meaning of 'have' and 'have not', the moral coding of AI and automation, and age riots
- at the bottom, he includes a list of global gamechangers ie. major events that would have a fundamental impact on the course of the future eg. a global trade collapse, a rogue asteroid or a major sovereign debt default.

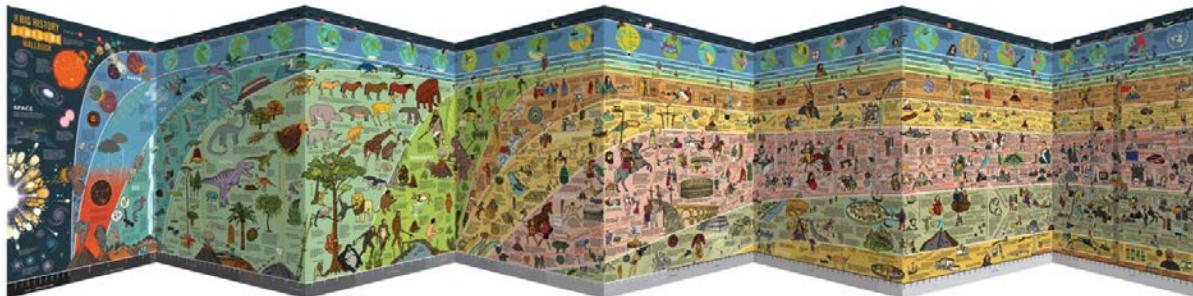
The elegance of Watson's design means that a vast amount of information is presented without overwhelming the reader (or this reader at least!).

The complexity of the topics he includes and their inter-relationship with each other could only have been communicated in a visual format. Explaining the relationships just using text would have been completely impossible.

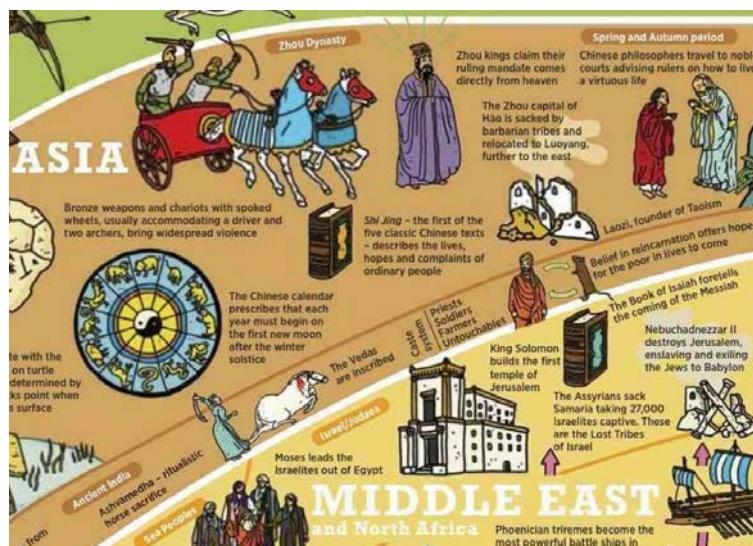
ii) Big History Timeline Wallbook

The [Big History Timeline Wallbook](#) is a large-format hard cover book with an inner page that expands out to a width of 2 metres.

The visual timeline starts with the Big Bang and continues right up to 2015. Initially the focus is on the physical and natural world with channels for space, earth, sky and nature. As humans come onto the scene, these initial channels narrow and more space is given to what is happening on the different continents.



The format provides illustrations along with explanatory text, as can be seen below.



I think there is something incredibly exciting in seeing the Walbook stretched across the floor and getting a sense of the enormous scale of history. It's an experience that a diagram in a book just can't deliver.

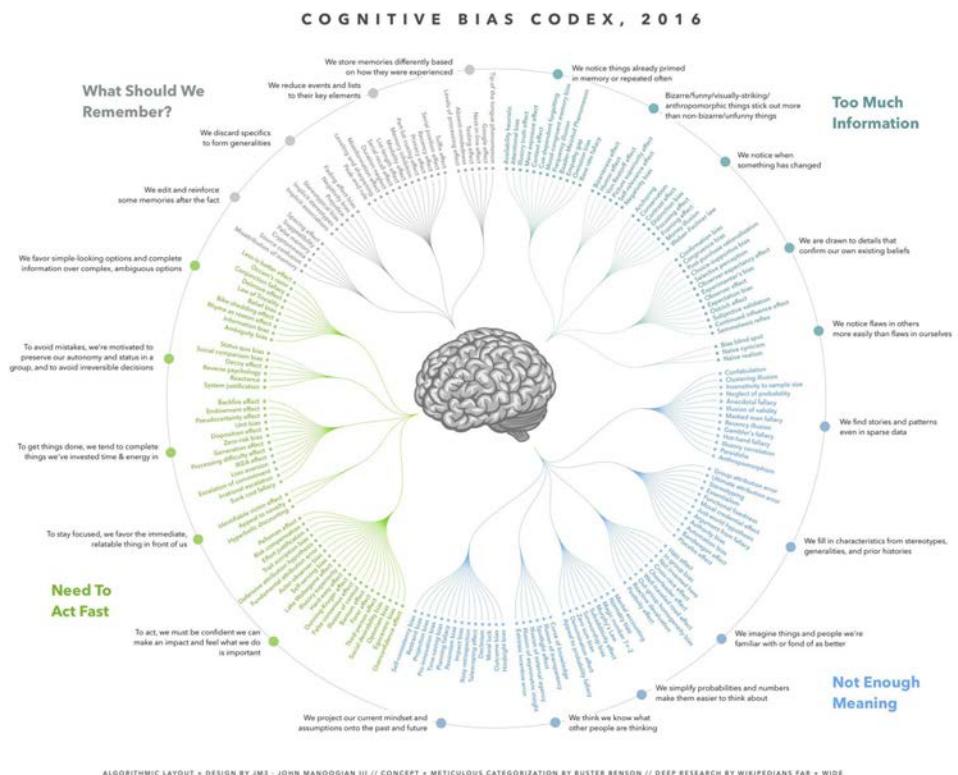
Christopher Lloyd, who created the Wallbook along with illustrator Andy Forshaw, identifies one important aspect of big knowledge maps: there is no one linear path to take through them.

As [Lloyd writes](#):

"Imagine a book that will be your guide – in pictures and words – where you don't have to start at the beginning and read to the end following the arbitrary path of an unknown author! No, you can start in the middle or wherever your interests lie and read left, right, up or down – without ever getting lost because of the timeline beneath! This is more what nature intended, because you may go wherever your curiosity leads!

“For me the joy of telling big stories is like the Wallbook itself, it has no beginning and no end. It is just a constant fascination with connecting together the dots of the past, giving them meaning and making them memorable through visualization, context, cause and effect.”

iii) The Cognitive Bias Codex



The [Cognitive Bias Codex](#) was created by John Manoogian from Buster Benson's work on categorising cognitive biases. It's another map created on a grand scale with the large version measuring 3ft by 2ft (91.5 x 61cm).

Benson [has written](#) about how he had been using the [Wikipedia list of 175 cognitive biases](#) (ie. ways in which our thinking fails to interpret or represent reality adequately) for years. However the poor organisation of the list made it difficult for him not just to identify the right bias when he came across faulty thinking but also to remember them all.

He therefore decided to organise them more effectively. After discarding duplicate biases that had crept into the Wikipedia list, he grouped them into twenty different cognitive tendencies, which included:

- “we are drawn to details that confirm our own existing belief”
 - “we notice flaws in others more easily than flaws in ourselves”
 - “we fill in characteristics from stereotypes, generalities and prior histories”.

On trying to organise the tendencies further, he realised they could be grouped by “the general mental problem that they were attempting to address”. This he found made it “a lot easier to understand why they exist, how they’re useful, and the trade-off (and resulting mental errors) that they introduce”.

He identified the four problems that cognitive biases help us address as:

- having to deal with information overload
- having to make sense of things when the meaning isn't clear
- having to act fast even when there is uncertainty
- having to decide what is worth remembering.

After reading Benson's article, [John Manoogian](#) created the map shown above.

Not only is the map a thing of elegance and beauty, it is also supremely functional. It makes the collection of cognitive biases seem much less overwhelming than when written down in a long list. It is also much easier to travel through the information using the map rather than text:

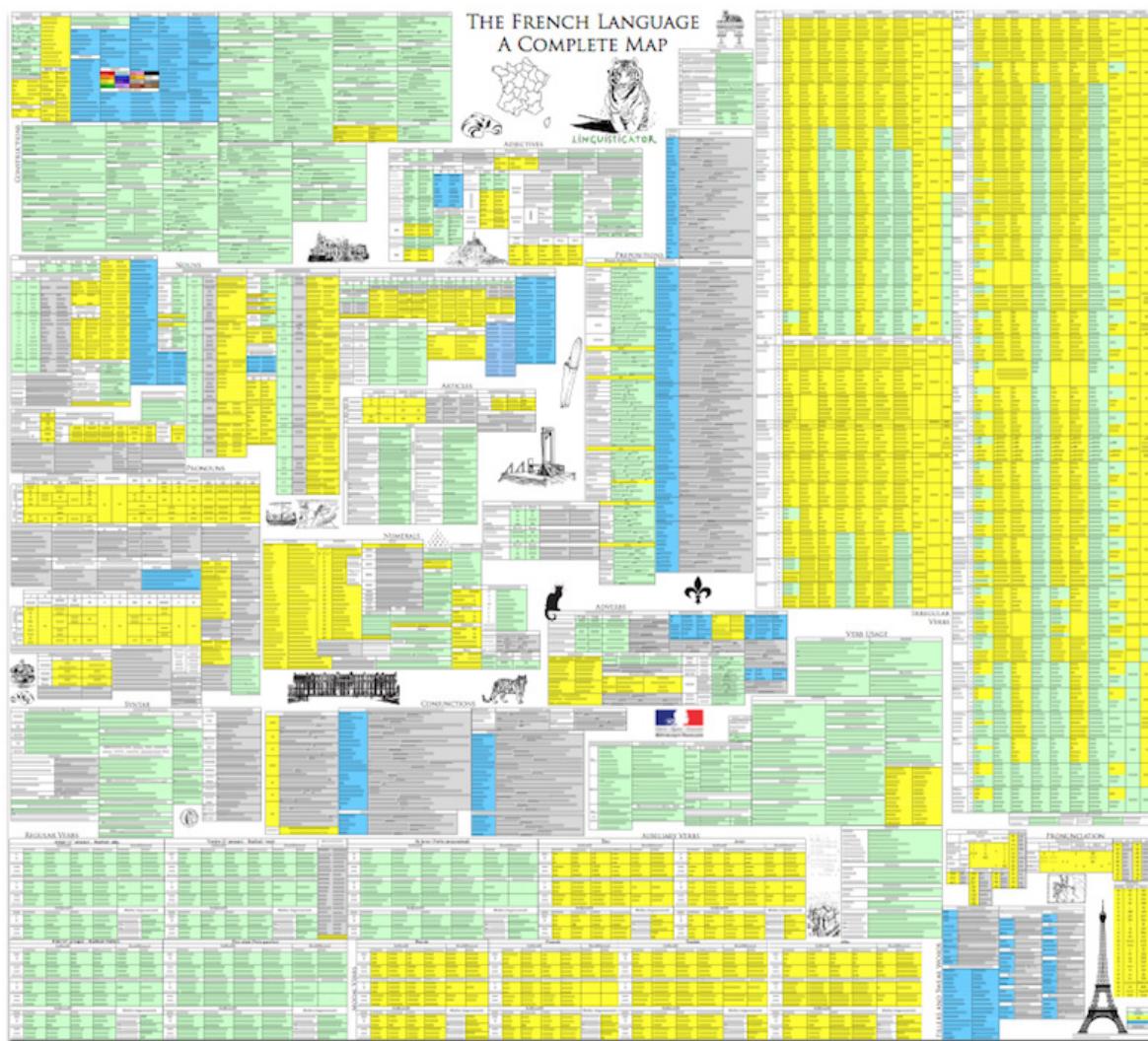
- one can start with one of the problems, look at the different tendencies related to that problem and see how they differ from the tendencies related to another problem
- one can start with a tendency of particular interest and then investigate the particular biases that comprise it
- when coming across some faulty reasoning, one can identify what problem it addresses, move to the tendency that it resembles and then try to identify the particular bias that it is an example of.

Of course, it is always possible to go back to the text description of a particular cognitive bias when one wants to explore it in more detail.

iv) Linguisticator language maps

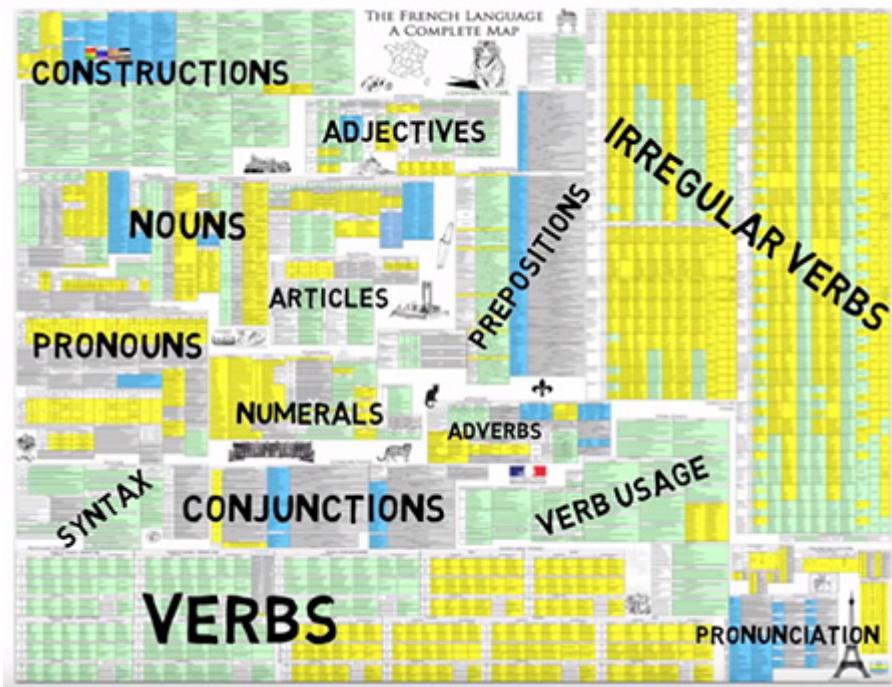
[Linguisticator](#), a Cambridge (UK) training company, have produced big knowledge maps of (so far) Arabic, French, German, Italian, Russian, Spanish and Turkish for their language training courses. They describe these maps as “comprehensive and exhaustive maps of the structure of each language” which “include every pattern, variation, and exception within the grammar of the language”.

Below you can see an image of their [French language map](#). It is another big map, measuring roughly 5 feet in width and 4 feet in height (142cm wide x 127cm high), and is printed on fabric.



The Linguisticator French language map

Below is a screenshot showing how the whole map is divided into different grammatical categories (from [video](#)).



More of the detail can be seen below with a section from the map giving information about masculine and feminine singular nouns.

| BOTH MASCULINE AND FEMININE SINGULAR | | | |
|--|--------|------------|--------------|
| | Masc | Fem | Masc |
| Singular | ami | amie | touriste |
| Plural | amis | amies | touristes |
| Formation of the Feminine from Masculine Nouns | | | |
| Masc | Fem | Examples | Exceptions |
| -an | -anne | paysan | paysanne |
| -at | -ate | rat | rate |
| -et | -ette | cadet | cadette |
| -ot | -ote | bigot | bigote |
| -é | -ée | décédé | décédée |
| (i)er | (i)ère | fermier | fermière |
| Gender-specific animal names | | | |
| -en | -enne | Italien | Italienne |
| -on | -onne | cochon | cochonne |
| -l | -lle | industriel | industrielle |
| -f | -ve | serf | serve |
| -x | -se | époux | épouse |
| -c | -que | Turc | Turque |
| -c | -cque | Grec | Grecque |
| -eur | -resse | pêcheur | pêcheresse |
| -eur | -euse | vendeur | vendeuse |
| -teur | -teuse | menteur | menteuse |
| -teur | -trice | acteur | actrice |
| | | M | F |
| | | le bétier | la brebis |
| | | le bouc | la chèvre |
| | | le cerf | la biche |
| | | le coq | la poule |
| | | le jars | l'oie |
| | | le cheval | la jument |
| | | le singe | la guenon |
| | | le taureau | la vache |
| | | le porc | la truie |
| | | l'hasse | |

Aaron Ralby, the creator of the maps, has [written](#) about the complexity of developing these maps and the benefits of providing comprehensive explanations:

“The process of creating a map of a language is time consuming and difficult. Were we to just map the main patterns of a language, it could be done in a matter of weeks; but the real value of the map is that it is exhaustive.

This allows us to put boundaries on the language for beginners and explain the complexities in a framework that can be easily understood. Did you know there are only seven words in the English language today that form their plural like tooth/teeth? Did you know that there are only 32 feminine strong nouns in German and all the rest behave according to a single weak pattern? Or that feminine nouns account for more than 50% of nouns in German, so by learning 33 nouns, you have learned more than half of the nominal system? These kinds of details are eye-opening, and cannot be discovered or known without someone first going through the laborious process of mapping.”

1.2.2 SMALL KNOWLEDGE MAPS

I define small knowledge maps as those which are A4 size or smaller

I have included examples of five here:

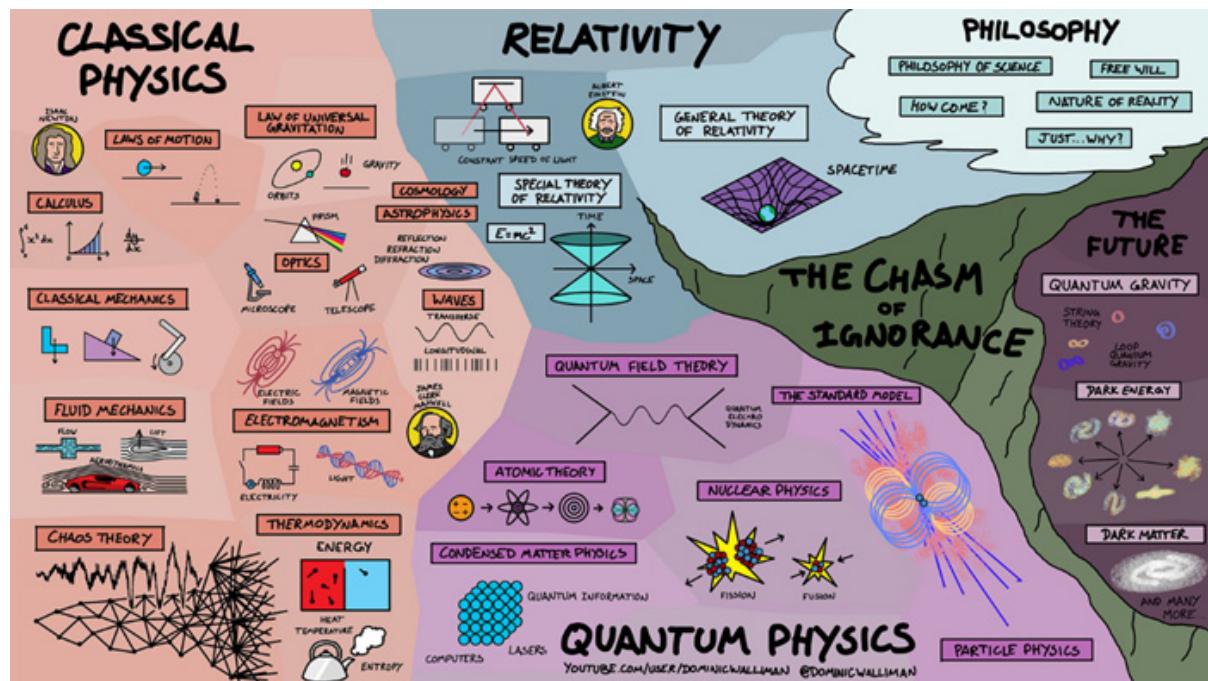
- a Map of Physics showing the different areas within physics
- a map explaining the rise of Hitler
- a map showing different literary periods in English literature
- a book summary of *All Out War* by Tim Shipman
- a book summary of *Deep Work* by Cal Newport.

i) Map of Physics

[Dominic Walliman](#) is a physicist and science writer, who also writes science books for children.

He has produced maps and accompanying YouTube videos describing the different categories and sub-categories of individual fields such as biology, chemistry, physics, mathematics and computer science.

Below you can see his Map of Physics. He divides the field into four main areas - classical physics, relativity and quantum physics, and adds a section for future discoveries that can only be reached by crossing the current chasm of ignorance.



Map link - www.flickr.com/photos/95869671@N08/30976775430/in/dateposted/

Link to explanatory video - www.youtube.com/watch?v=ZihywtixUYo

What I find fascinating about all his maps is how powerful a simple taxonomy can be. When we are learning new ideas, we often focus on a specific area without understanding the wider context it exists in. Seeing how all the different parts of a field fit together into categories and sub-categories creates two slightly opposing but positive experiences for me:

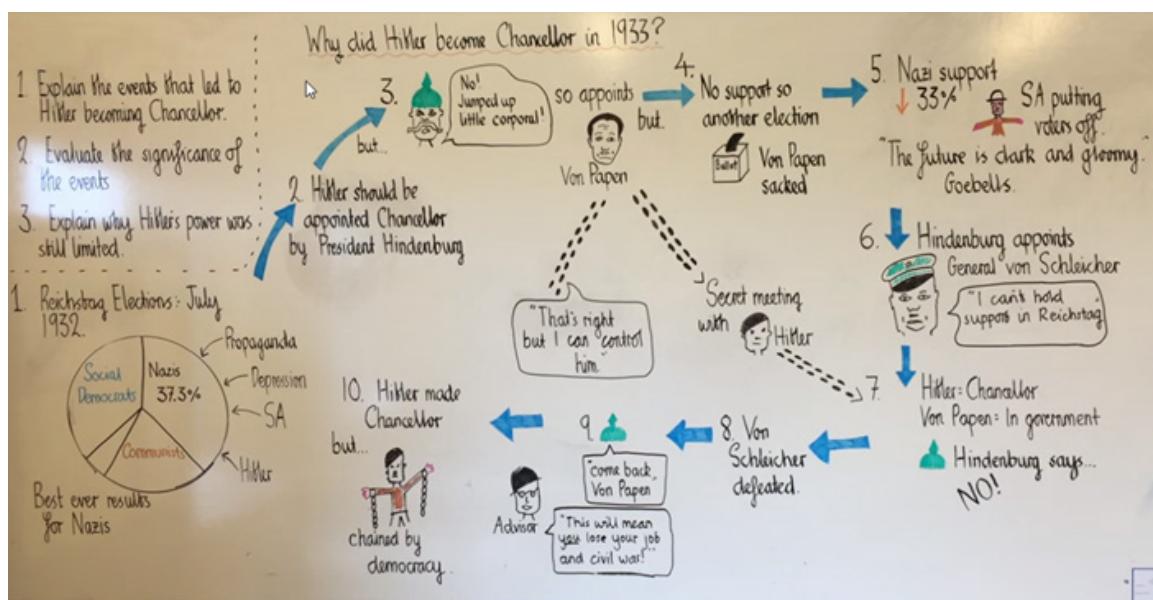
- firstly, I feel a sense of containment because, even though a field may be very big, the map shows that there are boundaries
- secondly, I experience a sense of expansiveness because of the hugeness of the knowledge contained in the field.

ii) The rise of Hitler

[Ben Newmark](#) is a history teacher who uses whiteboard knowledge maps as an integral part of his teaching.

I think his map below (for GCSE History) explaining why Hitler became Chancellor in 1933 is an excellent example of communicating information clearly but in an interesting way:

- the timeline clearly summarises what happened
- the quotes add drama
- the illustrations create interest and a sense of concreteness. However, by not being overly elaborate, they don't steal attention from the message.



His aim is to strengthen memory without creating excessive cognitive load. As he writes in a [blog post](#):

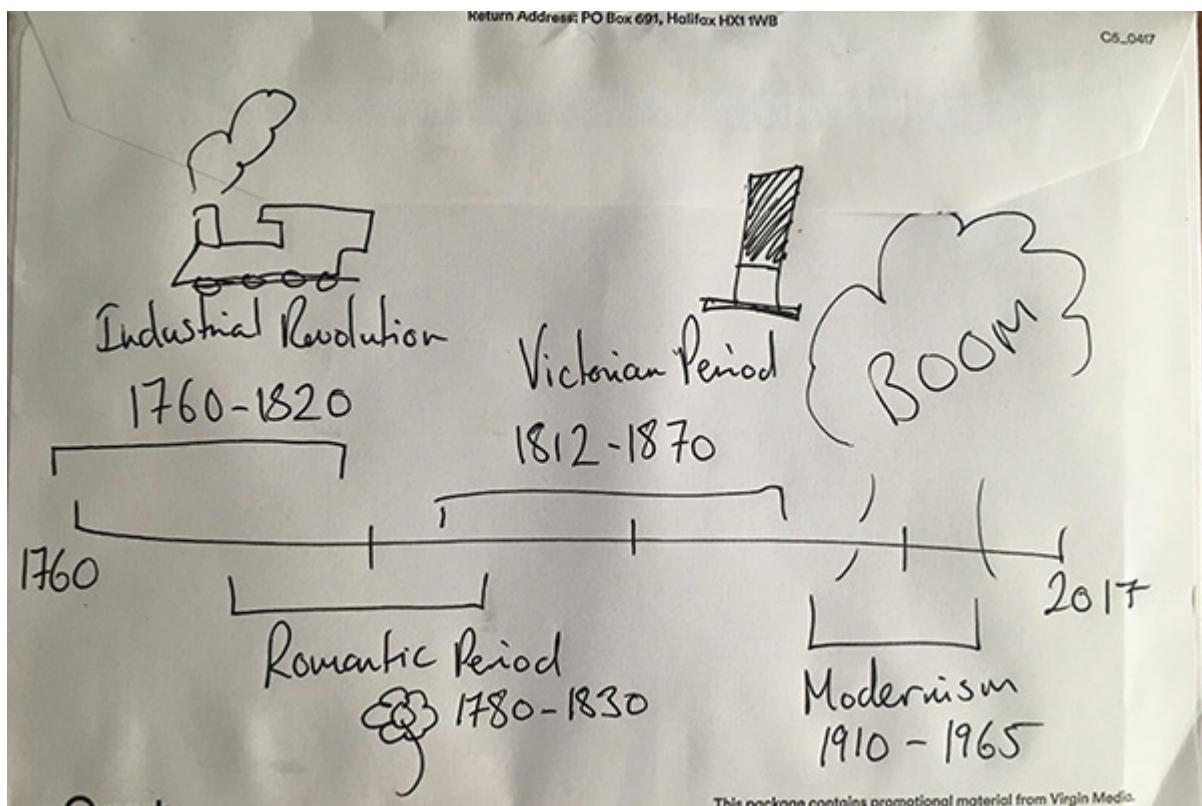
"Clear, neat illustrations and text reinforce and support explanations because presenting students with information in more than one way strengthens memory. However, any illustrations, whether they are hand-drawn on a whiteboard or displayed on a LCD projector, should be neat, directly related to the content and referred to at the appropriate time."

"The key, as always, is strong subject knowledge and careful thought about the material being taught, which makes it far easier for a teacher to see which parts of the content would benefit most from visual reinforcement. Crowded boards or too many distracting images overload working memory and undermine the overall clarity of the explanation."

While the map was drawn on a whiteboard so that the whole class can see it, I don't categorise it as a big knowledge map as it could be created in a smaller format.

(Screenshot taken from [video](#))

iii) Literary periods in English literature



With his map of literary periods in English literature, Mr Pink ([@Positivteacha](#)) shows that knowledge maps don't need to be hugely complex or detailed. And as this map seems to have been drawn on the back of a direct mail envelope, it also shows knowledge maps don't need to be polished in order to be valuable.

Mr Pink has written a fascinating [blog post](#) about how his students have benefitted from being taught this simple timeline showing the different literary movements that developed after the Industrial Revolution from the Romantic Poets and the Regency Period (Jane Austen) to the Victorian Period (Charles Dickens) and Modernism (James Joyce, F. Scott Fitzgerald and T. S. Eliot).

The map allows him to explain to his students how writers wrote not just in response to the political, economic and social change they saw around them but also sometimes as a reaction against the worldview of writers from the previous generation.

He writes:

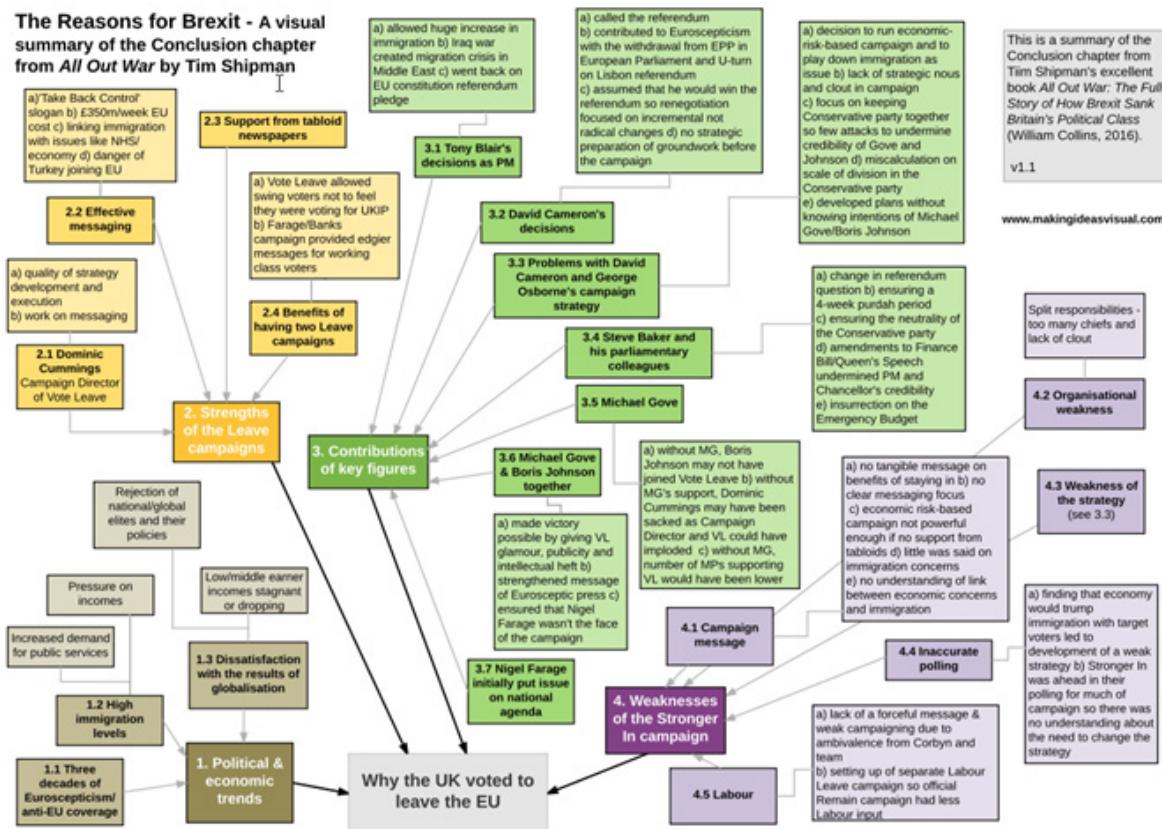
"[It] is a hastily drawn Timeline that all students of English Literature could do with knowing. I've found that giving my students a basic understanding of the literary periods - and the rough ... times during which they occurred has proved valuable, particularly when it comes to context questions such as the Eduqas poetry anthology exam, in which candidates are expected to know the contextual information of 18 different poems, spanning 3 centuries."

His blog post is a recommended read not just to find out what he has done but also because his analysis of the relationship between different literary periods is really interesting in itself.

Mr Pink's map is more minimalist compared with some of the other maps described here and it would be entirely possible to produce a more elaborate map with extra detail.

However, even in its simple state, it does a good job of showing the wider context that the writers existed in. From what he has written, I'm sure that it not only makes learning more interesting for his students but it also helps them to have more sophisticated insights into the work of individual writers.

iv) A summary of *All Out War* by Tim Shipman



Full size image - http://www.makingideasevisual.com/wp-content/uploads/all_out_war_summary_1_1.pdf

This is a map I produced from the Conclusion chapter of Tim Shipman's book *All Out War: The Full Story of How Brexit Sank Britain's Political Class* (William Collins, 2016).

Tim Shipman's Conclusion is clearly written, as indeed is the whole book. However, the story he summarises is complex, and it can be hard to keep the different categories and individual causes in one's mind. I have found that having this summary provides a great deal more clarity.

Of all the examples I have shown, this is the knowledge map that has the most explanatory text on it. Most of the other maps are at higher levels of abstraction as they are describing a more top-level picture and so they feature less detail. As different maps focus on different contexts and have different explanatory objectives, they will all vary.

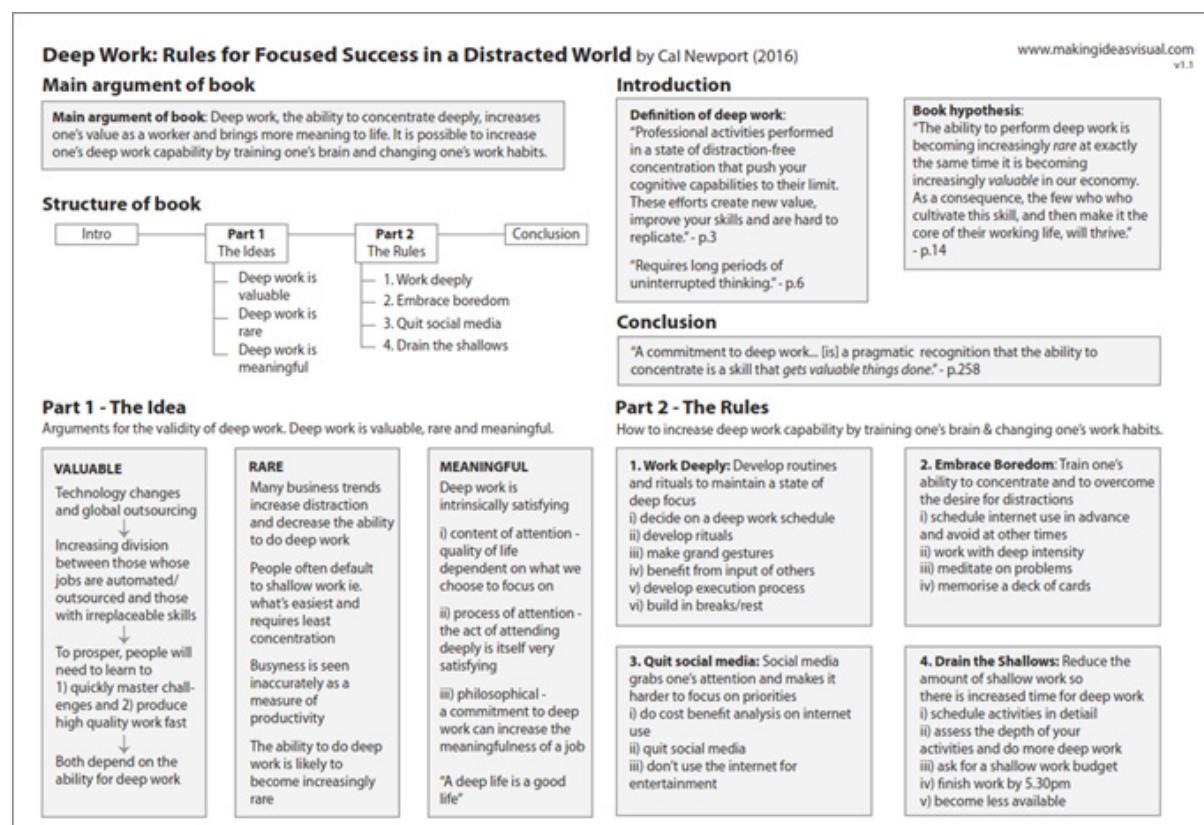
Each of the other chapters in the book could themselves have knowledge maps. That goes into the realm of hierarchical knowledge organisation, which I will be looking at later on in the paper.

iv) Summary of *Deep Work* by Cal Newport

Below is another visual summary I produced of Cal Newport's book *Deep Work: Rules for Focused Success in a Distracted World*. Apart from a diagram of the book structure, it just includes text within tables without any representational graphics.

The aim was to show the structure of the book and to extract its key ideas so that readers had a framework to:

- a) understand the big picture of the book before they started reading it in detail
- b) refer back to if they had had a break from reading the book and needed to refresh their memories about the general themes they had already read
- c) remind themselves about the book's ideas after they had finished reading it.



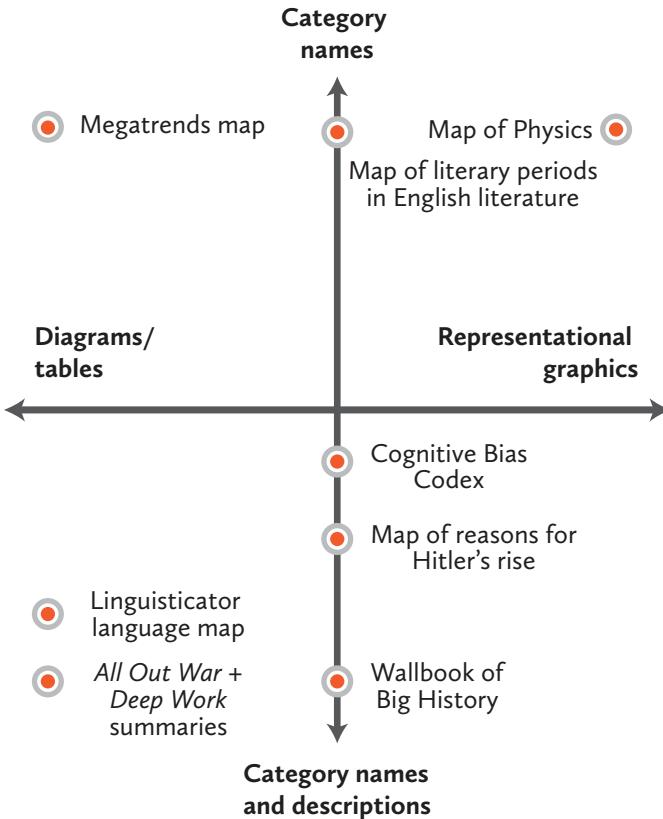
Link to full-size document - www.makingideasvisual.com/wp-content/uploads/dw_book_summary_1_1.pdf

1.2.3 CATEGORISING KNOWLEDGE MAPS

All these knowledge maps can be categorised in two ways:

- i) the format they use
- ii) the type(s) of knowledge structure they use.

Categorising knowledge maps by format



I have created a simple framework to categorise the format of the different maps.

The horizontal axis describes how the map uses graphics:

- a) abstract graphics (eg. diagrams, flowcharts and/or timelines) and tables
- b) representational graphics (which include illustrations, graphic icons and/or photographs)
- c) or a combination of both.

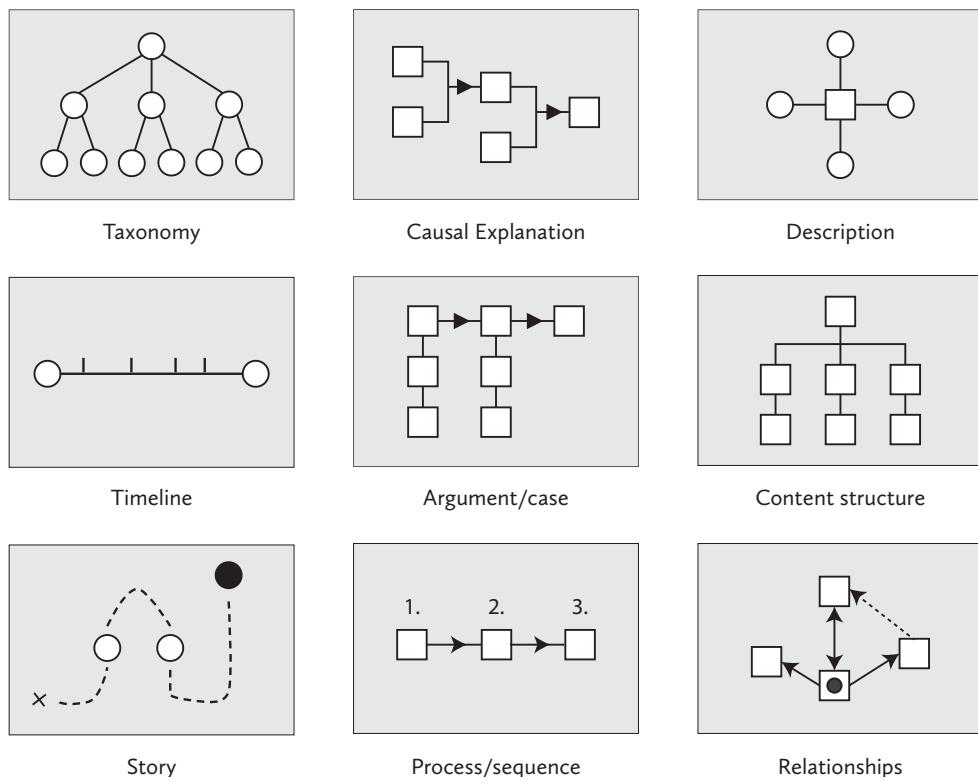
The vertical axis describes the use of categories and explanation: ie. whether a map uses just category names or a combination of category names and descriptions.

Both of the axes represent a continuum rather than an either/or choice.

In Appendix 1, I explain in detail the rationale for my categorisation.

Categorising knowledge maps by knowledge structure

Earlier in the paper, I described a number of different knowledge structures and I've reproduced the graphic of the different types again below.



Each of the knowledge maps follow one or a combination of these knowledge structures:

- Megatrends map - Description
- Big History Timeline Wallbook - Timeline + description
- Cognitive bias codex - Taxonomy
- Linguisticator map - Taxonomy + description
- Map of physics - Taxonomy
- Hitler's rise - Causal explanation + timeline
- Literary periods in English literature - Timeline
- All Out War book summary - Causal explanation + description
- Deep Work book summary - Description + content structure

1.2.4 COMBINING KNOWLEDGE MAPS WITH EXPLANATION

Maps, by definition, show the big picture and therefore only provide a summary of information. Geographical maps can often be read on their own but that depends, to some extent, on the reader having pre-existing knowledge of the geographical areas.

However most knowledge maps, and particularly those one that consist solely of category names, require further explanatory detail to be useful or understandable.

This explanation can be provided in either a spoken or written format.

Examples of written explanation include:

- a book
- an article or paper
- a web page
- a blog post.

Examples of spoken explanation include:

- a talk or lecture
- a classroom explanation
- a YouTube video
- a presentation.



Below is a description of the different ways in which the knowledge maps I've described are combined with extra explanatory detail.

Mega Trends and Technologies map - Richard Watson's book [Digital vs Human: How we'll live, love, and think in the future](#) - and his talks (for example, www.youtube.com/watch?v=Aj6suRgTcdc)

Big History Timeline Wallbook - Christopher Lloyd's book [What on Earth Happened?: The Complete Story of the Planet, Life and People from the Big Bang to the Present Day](#) as well as many other history and science books that elaborate on the events described

Cognitive Bias Codex - Buster Benson's [first](#) and [second](#) articles/the [Wikipedia summaries of cognitive biases](#)

Linguisticator language maps - [accompanying course videos](#)

Map of physics - [YouTube video](#)

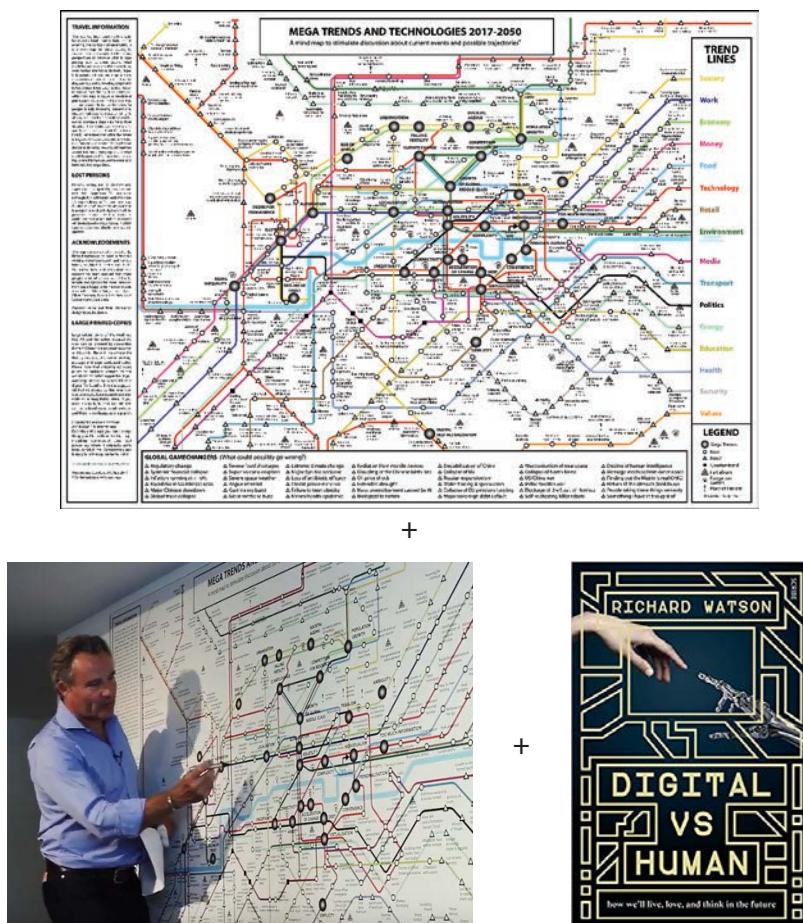
The rise of Hitler - spoken explanation in a classroom and on a [YouTube video](#)

Literary periods in English literature - [written explanation in a blog post](#)/spoken explanation in a classroom

Summary of All Out War - the map was created from Tim Shipman's book [All Out War: The Full Story of How Brexit Sank Britain's Political Class](#)

Summary of Deep Work - the map was created from Cal Newport's book [Deep Work](#)

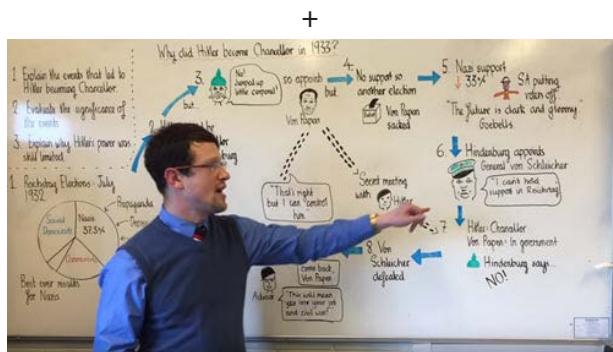
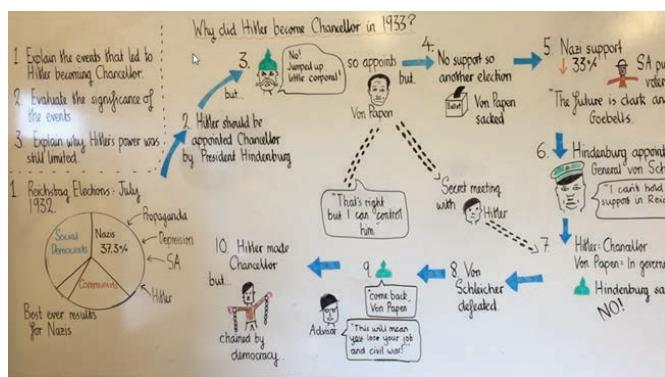
Here are illustrations of three of the combinations of map and explanation.



Mega Trends map explained in talks and a book



French language map explained in an online training course



Map of Hitler's rise explained in a classroom explanation and a YouTube video

Obviously the length of the explanation depends on the requirements of the audience and what needs to be communicated. There can be lengthy explanations as well as short explanations. Where only a summary explanation is needed, knowledge maps that also include extended descriptions (as with the book summary of Tim Shipman's *All Out War* book) can be used both as the map and the explanation.

It is my belief that, in general, knowledge maps and explanations belong together. An explanation without a knowledge map makes the explanation harder to understand and remember. Knowledge maps without explanations rarely provide enough detail.

1.2.5 BIG VS SMALL KNOWLEDGE MAPS

Big and small knowledge maps each have their pros and cons.

Big maps

Big knowledge maps work when there is a large amount of information that needs to be presented. Part of the impact that big maps have is that their size conveys the extent of a subject area. The fact that the Big History Timeline Wallbook is 2 metres long and has to be laid out on the floor or pinned up on a long wall to be read conveys the sheer length of history from the Big Bang to the present day in a very tangible way.

In addition, big maps allow large amounts of information to be presented in one place so that all the connections between different elements can be seen together. It would have been simply impossible to communicate all information shown in the Megatrends and Technologies map using text. Describing all the relationships between trends just couldn't be done in an understandable way.

However, big knowledge maps can also be overwhelming. The quantity of information on them means that people can feel that they are drowning in too much detail and therefore struggle to understand the big picture.

Another drawback is that they can be very time-consuming to create and require access to graphic design skills if they are to look professional.

Smaller maps

Smaller knowledge maps can be easier and quicker to produce, and work well for more constrained areas of knowledge. However they cannot include the amount of detail that can fitted on to big knowledge maps.

Getting the best of both worlds

There will be some occasions when a big knowledge map is needed to provide a large amount of detail but smaller maps are required to show the big picture. Later on, I will show how creating a series of maps at different levels of detail can provide the best of both worlds.

1.2.6 The benefits of knowledge maps

The benefits of knowledge maps for learners

Here are some of the many ways learners can benefit from the provision of knowledge maps:

- one can pack large amounts of information into knowledge maps, as can be seen from many of the examples given
- knowledge maps can show the relationships between elements, which would be confusing to explain using just text or spoken words
- having many ideas, concepts and/or facts combined in a knowledge map allows learners to make new connections for themselves
- knowledge maps can help to simplify knowledge. Because maps have to be summaries, only the most critical information is included
- by showing the content of a field in a single document, that field can become more knowable and less daunting to new learners instead of seeming like a mass of overwhelming, unboundaried information
- one of the problems of the modern world is information overload. The categorisation imposed by knowledge maps helps stop information overload by putting ideas in their context
- knowledge maps make knowledge more accessible. The big picture viewpoint of maps allows an initial scan to give a quick grasp of the material and makes information easier to find
- knowledge maps can make knowledge more concrete. Combining abstract and/or representational graphics with text or words can make knowledge feel more real than when it is communicated just with text or words. As a result, knowledge maps can help to make knowledge more inviting and interesting.

Knowledge creation

The process of making knowledge maps isn't just about creating visual representations or frameworks of existing knowledge ie. mapping what is already known.

It can also stimulate the creation of new knowledge, by:

1. identifying gaps in existing knowledge and new patterns
2. developing new and more useful categories or frameworks.

1. IDENTIFYING GAPS IN EXISTING KNOWLEDGE AND NEW PATTERNS

Aaron Ralby of Linguisticator found that the exhaustive maps he wanted to provide for students learning a foreign language didn't exist so he had to spend a great deal of time and energy on creating them.

He [has described](#) how he finds the metaphor of Mendeleev's periodic table useful for understanding his language maps:

"The periodic table is a map, a distillation of complex information into an artificial form that performs two key functions: first, it allows us to see patterns otherwise not visible, and second, it gives us a framework to explain the complexity of a subject to a non-expert. When Mendeleev put the elements into the periodic table, the gaps became evident in a way that would not have been nearly as clear as if they had all been presented in a single disorganized list.....

"With language, mapping as an exercise is very similar to what's described above. It takes an expert (or group of experts) to be able to distill a language's structure to expose the underlying patterns. When we start breaking elements of language into their component parts, patterns start to emerge even within the most irregular pieces. The irregularities of verbs in Romance languages are not completely random as they may first seem, but fall into set patterns of their own. German nouns are gendered according to patterns of ending and usage. Arabic verbs – which seem infinitely complex – fall into patterns of root changes and affixes that stretch across forms and conjugations. By mapping, order emerges from apparent chaos – an order that was there all along, but impossible to see without the map."

2. DEVELOPING NEW AND MORE USEFUL CATEGORIES OR FRAMEWORKS

The Cognitive Bias Codex is an excellent example of the benefits of creating new and more useful categories. As Buster Benson found, having a simple list of 175 cognitive biases wasn't a particularly effective way of organising the information.

By re-organising them into:

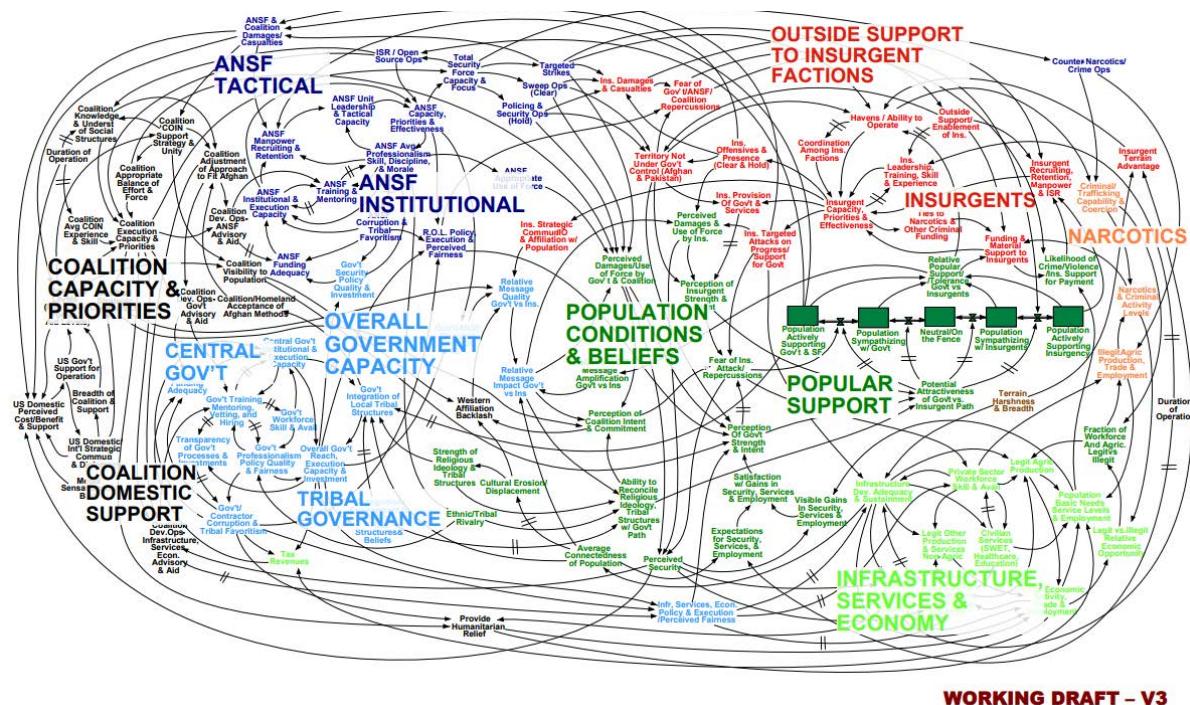
1. the four problems that cognitive biases address and
2. the 20 different cognitive tendencies,

he provides an opportunity for people to understand the different purposes and types of cognitive bias in a much more usable and in-depth way.

1.2.7 POTENTIAL PROBLEMS WITH KNOWLEDGE MAPS

Obviously knowledge maps only work if they can communicate ideas effectively.

The map below is a causal loop diagram that analysed the US's counter-insurgency strategy in Afghanistan in 2009.



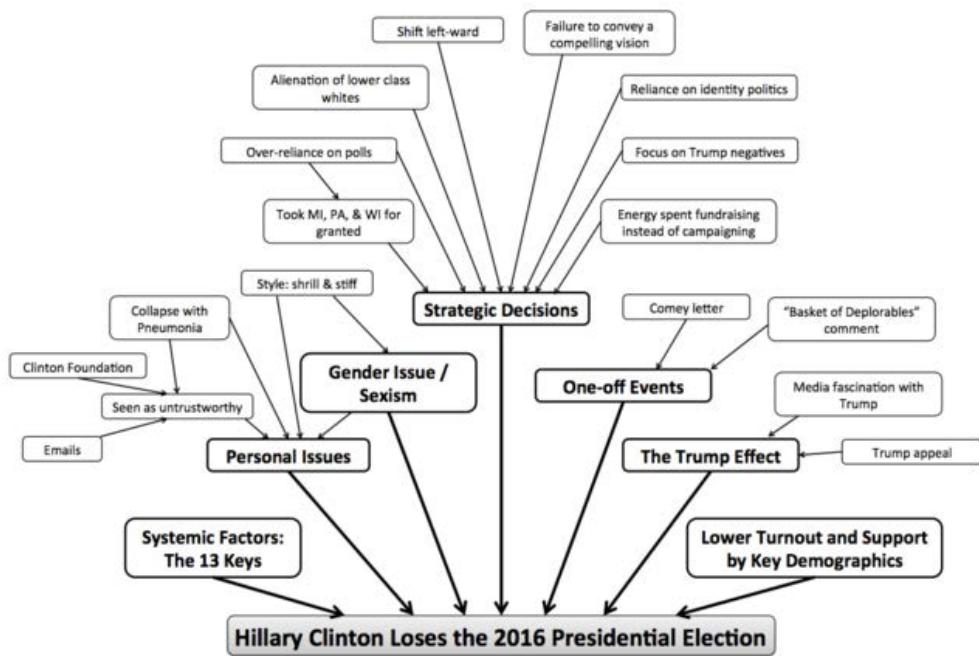
The complexity of the diagram was widely criticised and General Stanley McChrystal, the US and NATO commander in Afghanistan at the time, was said to have remarked: "When we understand that slide, we'll have won the war".

While the people working on the model felt they needed to include the many different factors and the numerous feedback loops in order to make the model as accurate as possible, they should have realised that people seeing the diagram for the first time were in danger of being overwhelmed.

One potential solution to this problem of complexity has been suggested by Gary Klein, a US research psychologist and an expert on decision-making. (I've written a blog post about his analysis of the 2016 US Presidential Election [here](#).)

He has developed the concept of causal landscapes to get away from the common tendency to provide excessively simple explanations for events and to assume that eventual outcomes were always inevitable. So he understands the need to include multiple causes. However he also understands that not all causes have the same impact and that it is important to differentiate the most impactful ones from less important ones.

The following gives an illustration of how he accomplishes this in practice, taken from his article on [why Hilary Clinton lost the 2016 US Presidential Election](#). The first stage in developing a causal landscape is to identify a wide variety of causes and to group them into relevant categories, which he has done in the graphic below.

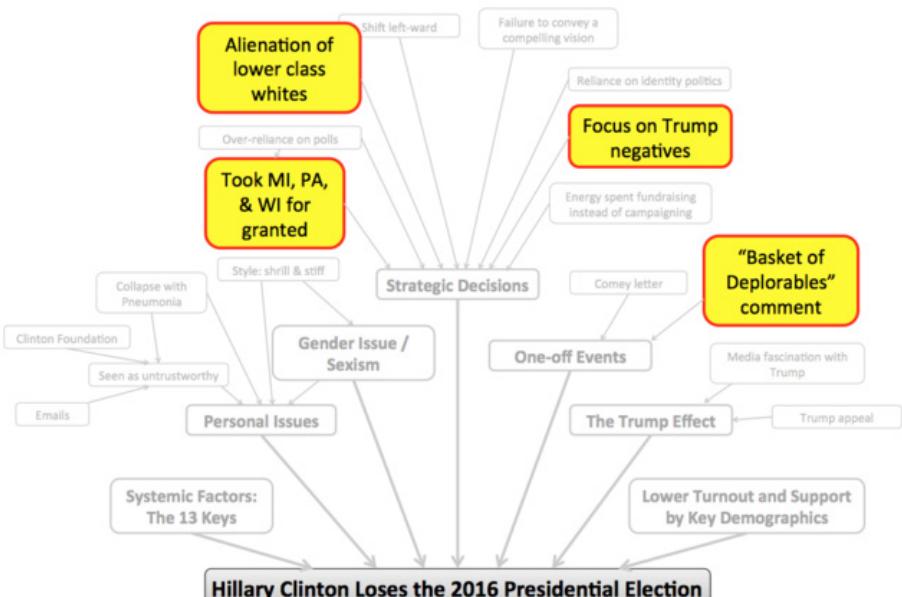


The second stage involves working out which of the most important causes would have been easiest to change and could therefore have affected the outcome.

He does this by asking “which of the causes shown in the diagram would have been the easiest to reverse, and which of the causes, if reversed, would have had the greatest impact?”.

His analysis suggests that there were four causes that might have swung the election for Hilary if they had been reversed or not happened: three of the campaign’s strategic decisions (taking Michigan, Pennsylvania and Wisconsin for granted; having attitudes that alienated lower-class whites; and an emphasis on Trump’s negatives rather than developing a positive vision); and the ‘Basket of Deplorables’ comment.

He then amends the original graphic to highlight these causes.



This immediately simplifies discussions by allowing a debate about whether the most impactful causes have been correctly identified and then about what can or could have been done about those causes.

Another solution is to create multiple knowledge maps showing different levels of detail. I will be discussing this in Part 2.

1.2.8 DIAGRAMS

Most of the knowledge maps described above are quite complex because of the complexity of the information being presented.

However we are all used to simpler diagrams in books and presentations. I will write more on this in a later blog post but I wanted to record here my belief that diagrams are very under-used, especially in many non-fiction books.

Not only can diagrams summarise the essence of an idea or a concept, they can also help to break up unending rows of text and so make content more inviting to read.

PART 2: THE PROBLEM OF MULTIPLE KNOWLEDGE LEVELS

In Part I, I explained how all knowledge has structure ie. constituent elements combine together in different ways to explain descriptions, concepts or ideas - and that visual knowledge maps are a very effective way of showing the structure of knowledge.

In this part, I am going to look at:

- the concept of hierarchical knowledge organisation
- how complex explanations require multiple connected levels in order to convey their meaning
- what this means for communicating knowledge more effectively.

2.1 THE CONCEPT OF HIERARCHICAL KNOWLEDGE ORGANISATION

2.1.1 FREDERICK REIF



The concept of hierarchical knowledge organisation³ has been developed by Frederick Reif, a physicist who originally worked in the field of condensed matter physics.

In the second part of his career as Professor of Physics and Education, firstly at the University of California at Berkeley and then at Carnegie Mellon University, he published work in the field of cognitive science and education.

The ideas on hierarchical knowledge organisation have been taken from the Organizing Knowledge chapter (Chapter 9) of his book *Applying Cognitive Science to Education: Thinking and Learning in Scientific and Other Complex Domains* (MIT Press, 2010).



³ This is different to educational sociologist Basil Bernstein's distinction between the hierarchical knowledge structures of the sciences and the horizontal knowledge structures of literature, social sciences and philosophy. For more information on Bernstein's ideas, see Andy Tharby's blog post - <https://classteaching.wordpress.com/2018/03/12/a-mastery-light-subject-curriculum-model/>.

2.1.2 THE ORGANISATION OF KNOWLEDGE

Reif starts with the question: "How can one effectively deal with large amounts of knowledge?"⁴ given the context of the "quite limited information-processing capacity" of humans.

For him, a critical part of the answer to this question is making sure that knowledge is organised effectively. This is because, as he writes, the organisation of knowledge "determines how readily the knowledge can be remembered, appropriately retrieved, kept consistent, communicated to others, and extended beyond its original scope". As a result, "instructional efforts need to pay as much attention to the organization of acquired knowledge as to its content"⁵.

2.1.3 THE ANALOGY OF GEOGRAPHICAL MAPS

Reif believes that geographical maps provide a suitable model for the effective organisation of knowledge⁶.

It would be completely impractical to have just one version of a world map that showed every single geographical detail of every country in the world down to the level of individual roads or buildings.

Problems would include:

- being far too large to be used practically
- each user having little use for vast amounts of the map
- the focus on the most detailed level meaning that users would struggle to get an overview of how higher levels like countries and regions relate to each other.

So the concept of maps has developed to deal with the problem of scale. Maps are produced showing different levels of detail:

- Level 1 – map of the world as a whole
- Level 2 - maps of countries as a whole (eg. US)
- Level 3- maps of individual regions (eg. the western, mid-western and eastern regions on the US)
- Level 4 - maps of states within individual regions (eg. for the western area, maps of Washington, Oregon and California)
- Level 5 - maps of cities and areas within individual states
- Level 6 - maps of individual parts of cities and other areas
- Level 7 – maps that go down to individual road and building level.

This allows us to travel from anywhere in the world to anywhere else in the world, using maps produced at various levels of scale.

In Reif's terminology, maps on one level get elaborated⁷ into more detailed maps on the next level down.

⁴ *Applying Cognitive Science to Education: Thinking and Learning in Scientific and Other Complex Domains*, Frederick Reif, MIT Press, 2010, p.142

⁵ Reif, p.161

⁶ Reif, pp.142-143

⁷ A relevant definition of the verb 'to elaborate' comes from the [American Heritage Dictionary](#): "to explain something at greater length or in greater detail".

2.1.4 KNOWLEDGE ELABORATION

Reif suggests that exactly the same process goes on with knowledge.

As with a map, if we are investigating a particular topic, there are different levels of detail that we might want to engage with at different times. For example, we might want to begin with the big picture or we might instead want to start with the detail.

Reif suggests that knowledge elaboration is a downward process starting with higher-level, more general knowledge, which “can be *elaborated* by specifying additional knowledge that is associated with it”⁸. As we shall see later on in this paper however, movement can go upwards as well as downwards.

Reif has described different types of elaboration⁹. These include going:

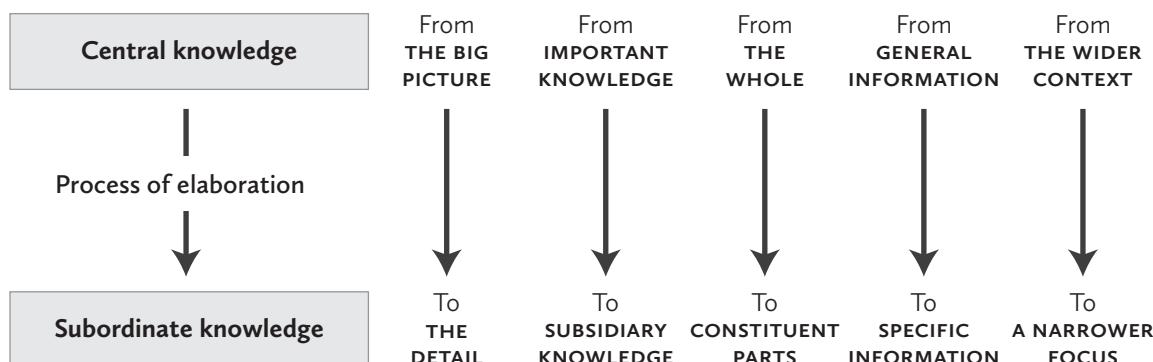
- from the big picture¹⁰ (Reif’s term is ‘coarse’ knowledge) to the detail ie. from a broad overview to in-depth descriptions
- from important (or core) knowledge to subsidiary knowledge ie. from ideas, facts and concepts of great significance or value to those of secondary significance or value
- from the whole to constituent parts or elements ie. from a complete description that brings together all the different parts to an examination of individual parts or sections
- from general information to specific information ie. from rules, principles or lessons that are true or mostly true to exceptions and anomalies.

I would also include going:

- from the wider context to a narrower focus ie. from an examination of the circumstances that helps to give meaning to a fact or concept to topics that are more limited in area or scope.

Reif writes that “this elaborated knowledge may be called *subordinate* (or *subsumed*) knowledge relative to the original knowledge” or ‘central knowledge’, as he also calls it.

This can be illustrated as follows:



⁸ Applying Cognitive Science to Education: Thinking and Learning in Scientific and Other Complex Domains, Frederick Reif, MIT Press, 2010, p.143

⁹ Reif, p.144

¹⁰ Definitions of the different terms related to elaboration can be found in Appendix 2.

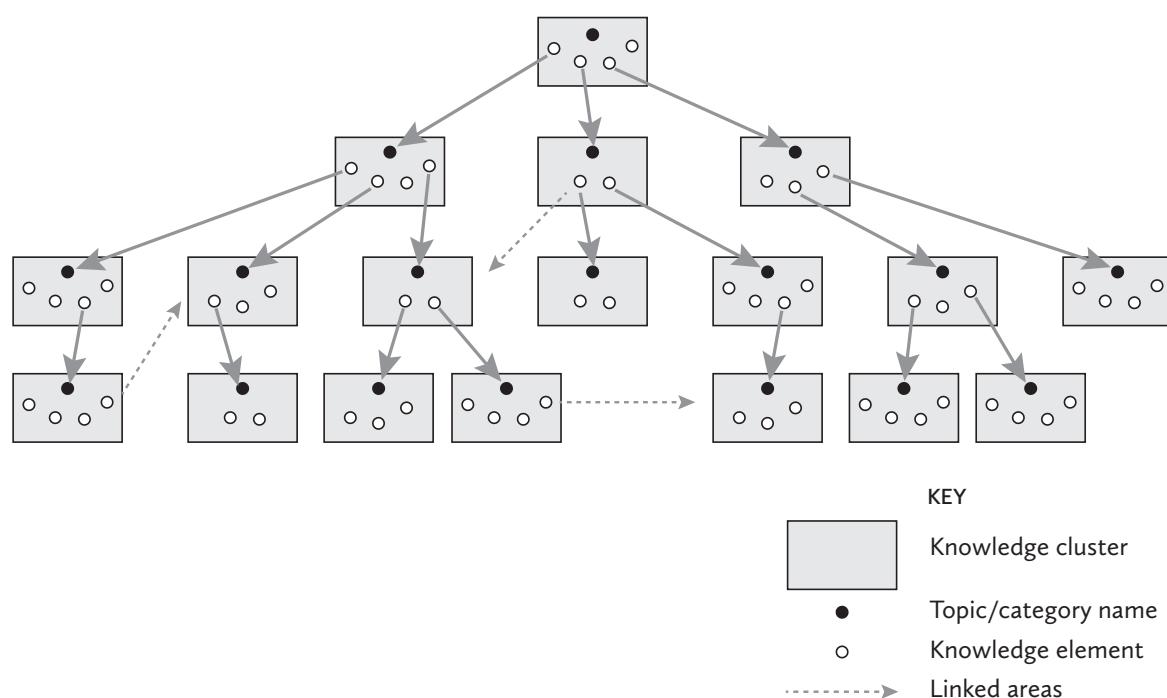
2.1.5 WHAT IS HIERARCHICAL KNOWLEDGE ORGANISATION?

Frederick Reif has developed the concept of hierarchical knowledge organisation out of this process of elaboration. At the top is a cluster of the most central or important knowledge elements related to a particular topic or category. Each of these elements can then be elaborated into more detail or more subsidiary knowledge in the subordinate knowledge clusters on the level below.

As with maps, this downward elaboration can go on for multiple levels. This means that if an element within a knowledge cluster on one level needs additional description, a further subordinate cluster can be added on the next level down. In this way, knowledge is organised hierarchically.

Another way of envisaging the relationship is to describe a knowledge cluster on a higher level as the parent cluster and the related clusters on the level below as the child clusters.

This is shown diagrammatically below.



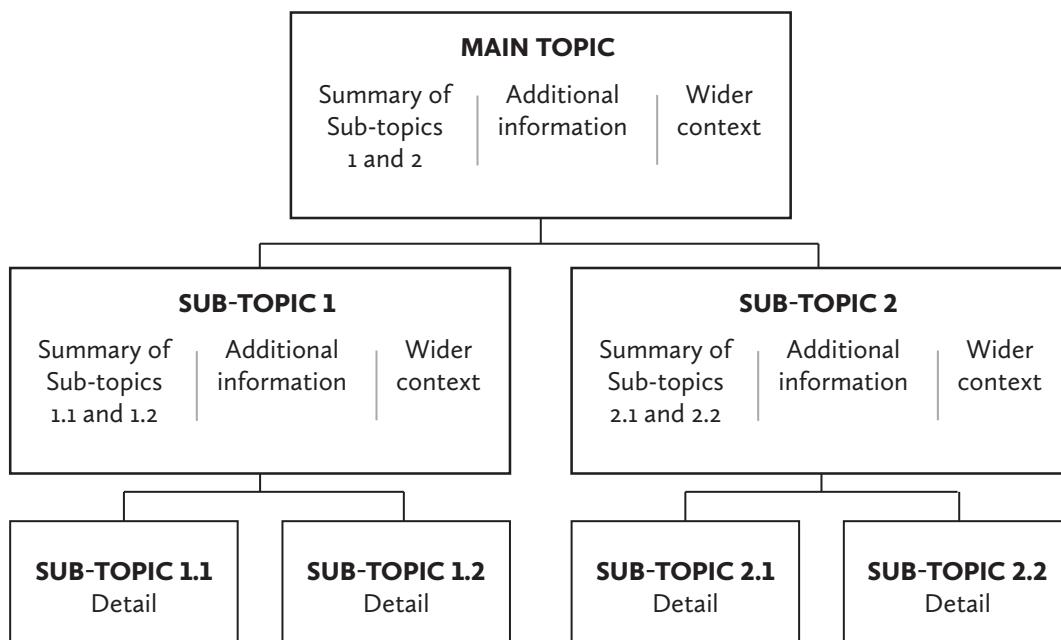
(This is a modified version of a diagram in Frederick Reif's bookⁱⁱ.)

Of course, elements can be linked to other knowledge clusters outside the elaborated hierarchy. In the diagram above, this is shown by the dotted grey line.

Higher level knowledge elements provide summaries of detail that is elaborated in related lower knowledge clusters. However there will also be some knowledge elements that don't require further elaboration and so contain all the detail needed for the particular explanation being given.

Another way of looking at the process of hierarchical knowledge organisation is shown in the simplified diagram below.

ⁱⁱ *Applying Cognitive Science to Education: Thinking and Learning in Scientific and Other Complex Domains*, Frederick Reif, MIT Press, 2010, Figure 9.6, p.145



The detail at the bottom (Sub-topics 1.1, 1.2, 2.1 and 2.2) is summarised in the knowledge clusters of Sub-topics 1 and 2 along with any other additional information relevant to those sub-topics and any information relevant to the wider context of those sub-topics.

On the next level up (the Main Topic cluster), those sub-topics are themselves summarised along with additional information about the main topic and information about the wider context.

The diagram describes three levels. In reality, there can be additional levels as well as additional topics on each level.

It's difficult to be precise about the optimal length of these summaries. They need to be long enough to provide useful information but they don't need to be so long that there's not a huge difference between the summary and the detail they are meant to be summarising.

2.2 Google maps: An analogy for understanding multiple knowledge levels

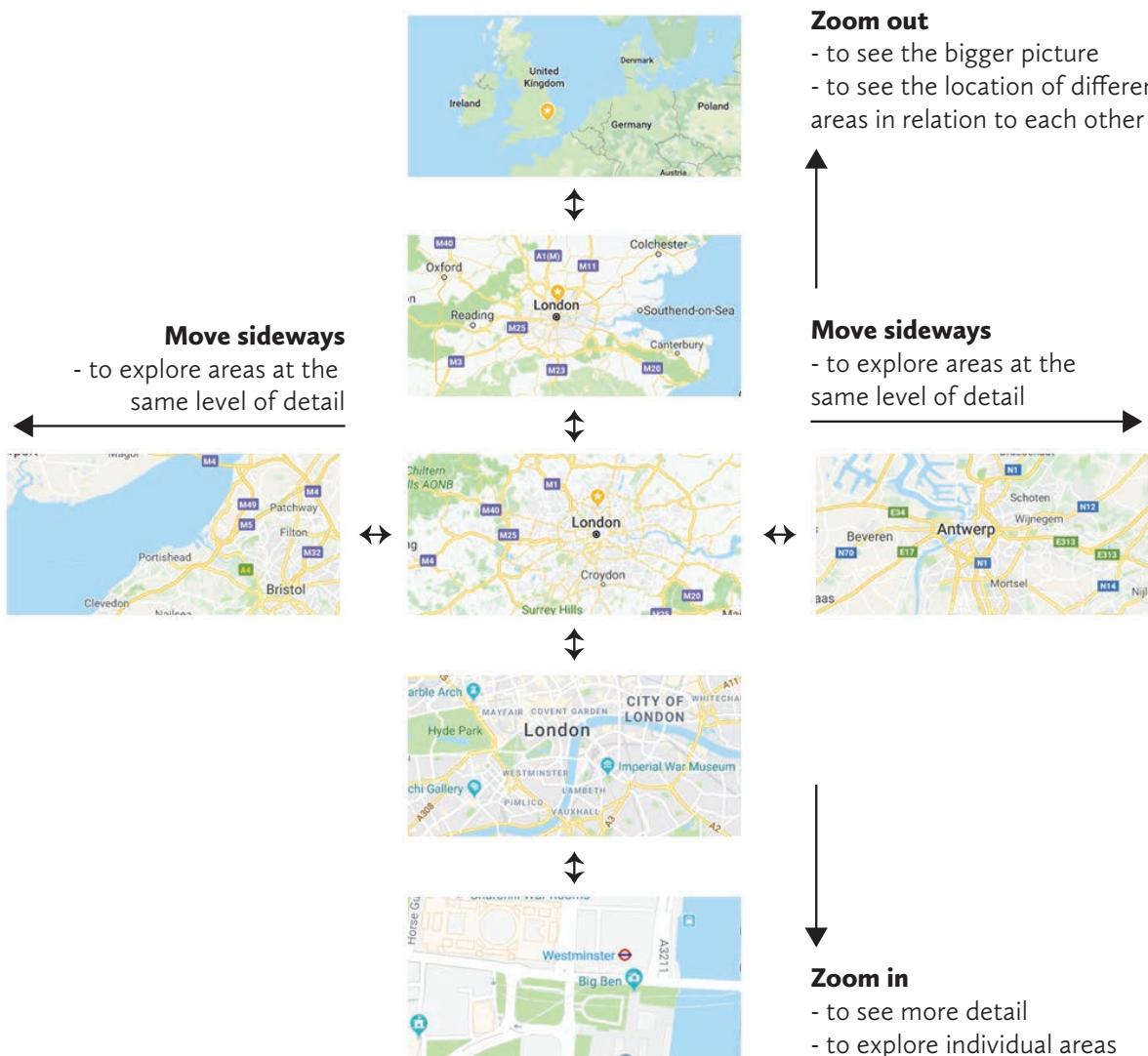
2.2.1 ZOOMING IN AND ZOOMING OUT

Google Maps provides a powerful analogy for understanding multiple knowledge levels and how hierarchies of knowledge can be navigated.

It allows users the choice of either zooming out to get a wider view or zooming in to get a more detailed view so that they can find just the right level of detail for their needs. They can also move across the map at each level of detail to look at both adjacent and distant areas.

So, for example, one can move from looking at a detailed map of a part of a London street all the way up on the broadest level to viewing London in relation to every other place in the world.

Using the plus and minus zoom controls in the bottom right-hand corner of Google Maps gives 19 levels of detail (including the top and bottom levels). Using a computer mouse provides more sensitivity and I counted 73 levels of detail scrolling from the most detailed level up to the top level.



The ability to zoom in for more detail, zoom out for the bigger picture or to move sideways is exactly what one needs to do when learning a subject or reading a book¹².

The model also suggests some strategies for teaching or communicating. Depending on the existing knowledge levels of particular audiences and their goals, one needs to decide whether one is using the appropriate level of detail.

Teachers and communicators have multiple options:

- go up a level or more to show the bigger picture by generalising, summarising or contextualising and therefore move away from excessive detail (zoom out)
- go down a level or more by providing more detail or by focusing on a particular aspect (zoom in)
- stay at the same level of detail, either in the same area (or, as Reif would describe it, that cluster of knowledge) or move to adjacent or more distant areas
- or combine a variety of these approaches.

¹² I recently came across a 2011 [blog post](#) by educational writer David Didau in which he used the same metaphor of zooming in and zooming out: "I asked students to think about camera shots and how films are put together. They easily grasped that analysing was like using an extreme close up and that evaluating was like using a wide or establishing shot. When film makers zoom in they get us to focus on tiny details and when they zoom out they reveal the big picture."

2.2.2 UNDERSTANDING THE PROCESS OF LEARNING

One way of understanding the process of learning is to see it through the lens of hierarchical knowledge organisation.

Learning a new area involves:

1. becoming familiar with more and more individual clusters of knowledge
2. having a better understanding of how those individual clusters of knowledge are connected within and between levels.
3. identifying what is important and what is subsidiary.

In all learning, there is a continual movement between understanding the whole and understanding individual parts. The whole is made more meaningful by learning details about the parts while the parts are made more meaningful by understanding how they relate to the whole.

Experts are able to zoom in and zoom out fast because they know all the relevant clusters and how they are connected. When they are confronted with a question or a problem, they know which area or areas they need to focus on. They also know how to strike the right balance between detail and the bigger picture.

2.3 Problem 2: The problem of multiple knowledge levels

The concept of hierarchical knowledge organisation suggests that all but the most simple explanations require multiple knowledge levels in order to be understandable.

The top levels of an explanation provide the big picture summary that draws together the threads of an argument or description. The top levels can also outline the more important elements of the explanation. The lower levels in the hierarchical structure provide the essential detail and subsidiary information.

The communication and understanding of knowledge suffers when these different knowledge levels aren't explicitly separated out or when some levels are missing.

As just discussed, a critical aspect of learning is being able to move continually between the big picture or the wider context and the detail - and between the core information and the subsidiary information - in order to build up an understanding of what one is learning.

Learners can struggle if:

- descriptions of the big picture or the core information are not marked out clearly but are instead hidden in a mass of detail or
- descriptions of the big picture or the core information are lacking and there is excessive focus on detail.

Different people also have different needs. Some may only require the big picture summary or an outline of the most critical elements. Others will, in addition, require more detail or subsidiary information. A lack of clearly differentiated knowledge levels adds more cognitive friction as people struggle to find the appropriate knowledge level or levels for their needs.

People also have different needs at different times. Someone starting a new book might welcome a general overview of the contents of the book before they are ready to become

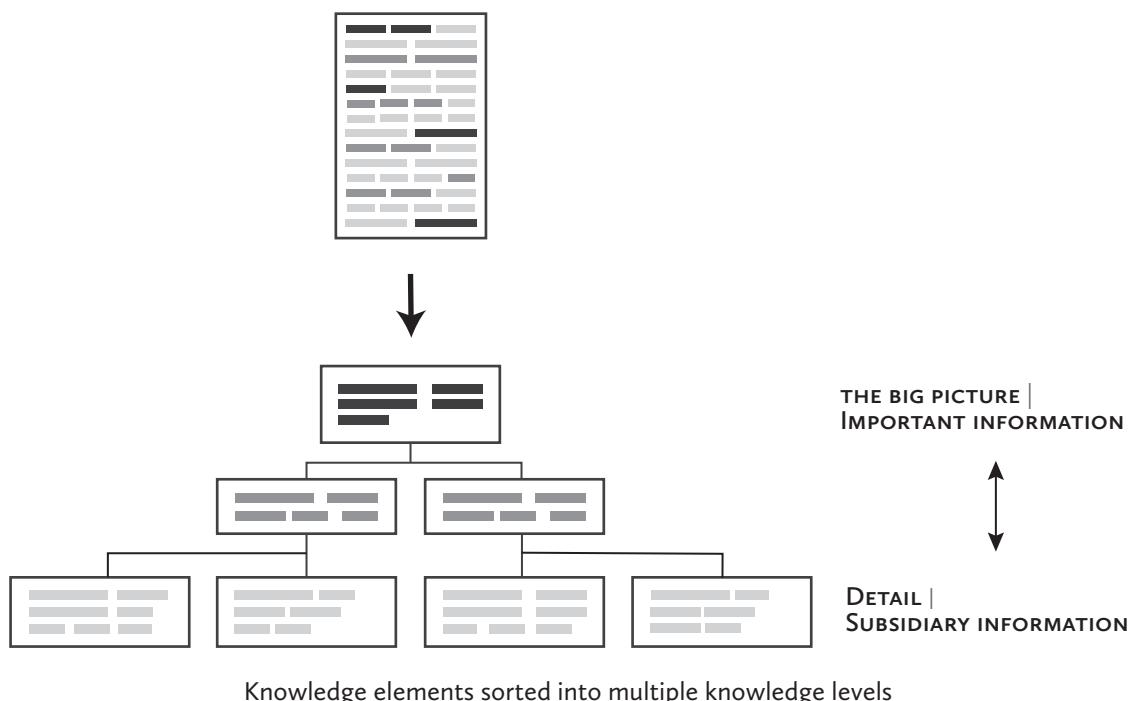
immersed in the detail. On finishing the book, they may then want to revisit the general summary to look at the big picture again or to help them embed the book's key ideas into their memory.

2.4 Solution: Filling in undifferentiated or missing content

There are two scenarios that relate to multiple knowledge levels.

2.4.1 SCENARIO 1: HIGHLIGHTING UNDIFFERENTIATED SUMMARIES

The first scenario is where the summaries of the different levels already exist but they are distributed throughout the text or speech with little indication that they providing overview or core information. The solution is to create differentiation by highlighting these parts. This makes it easier for the reader or listener to understand that these summaries are on a different knowledge level to the rest of the detail.



2.4.2 SCENARIO 2: ADDING IN MISSING CONTENT

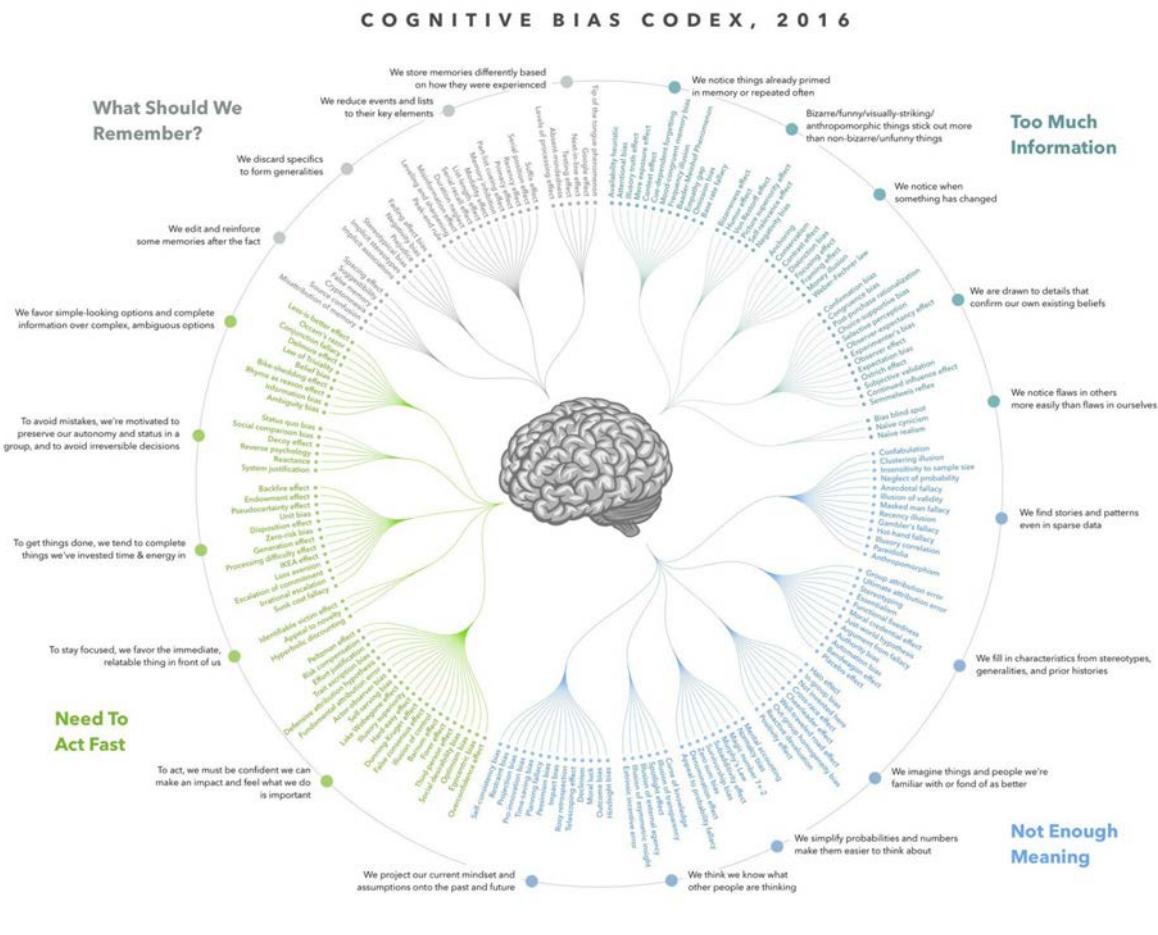
The second scenario is where whole knowledge levels or summaries of individual sub-topics have been missed out.

Using the metaphor of maps, this would be the equivalent, say, of having a map of the world and then detailed maps of regions within countries but with the maps of individual countries missing. One could mostly work out the information one needed but it would be much more of a struggle than if the level of individual country maps had been included.

The solution is to add in summaries of the missing areas.

The Cognitive Bias Codex

A good example of this is the Cognitive Bias Codex.



As discussed in Part I, Buster Benson started with [an article](#) categorising the 189 cognitive biases into four different problem areas and 20 cognitive bias categories, and providing links to each of the cognitive biases.

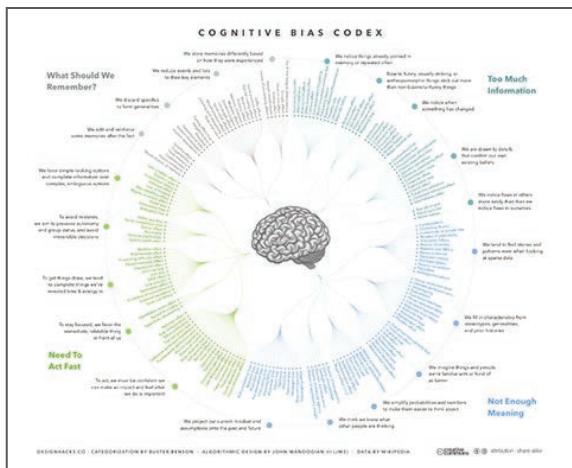
John Manoogian then produced a graphic of this categorisation, which you can see above.

We can take this as the baseline knowledge level. The combination of knowledge map and explanation is shown at the top of the next page.

KNOWLEDGE MAP

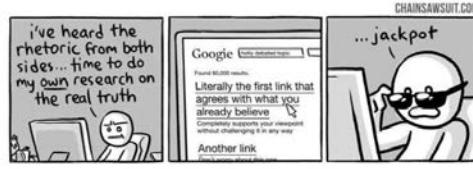
+

EXPLANATION



Cognitive bias cheat sheet

Because thinking is hard.



I've spent many years referencing Wikipedia's list of cognitive biases

whenever I have a hunch that a certain type of thinking is an official bias but I can't recall the name or details. It's been an invaluable reference for helping me identify the hidden flaws in my own thinking. Nothing else I've come across seems to be both as comprehensive and as succinct.

However, honestly, the Wikipedia page is a bit of a tangled mess. Despite trying to absorb the information of this page many times over the years, very little of it seems to stick. I often scan it and feel like I'm not able to find the

Concerned that the original article was too long (and possibly too complex), Benson wrote what he called [a simplified cheat sheet](#) four months later, which provided descriptions of the four problem areas along with single words or phrases to summarise the cognitive bias categories. The article also included a graphic produced by him summarizing the categorisation.

COGNITIVE BIAS CHEAT SHEET BECAUSE THINKING IS HARD



1 TOO MUCH INFO

- SO ONLY NOTICE...
- CHANGES
 - BIZARRENES
 - REPETITION
 - CONFIRMATION



2 NOT ENOUGH MEANING

- SO FILL IN GAPS WITH...
- PATTERNS
 - GENERALITIES
 - BENEFIT OF DOUBT
 - EASIER PROBLEMS
 - OUR CURRENT MINDSET



3 NOT ENOUGH TIME

- SO ASSUME...
- WE'RE RIGHT
 - WE CAN DO THIS
 - NEAREST THING IS BEST
 - FINISH WHAT'S STARTED
 - KEEP OPTIONS OPEN
 - EASIER IS BETTER

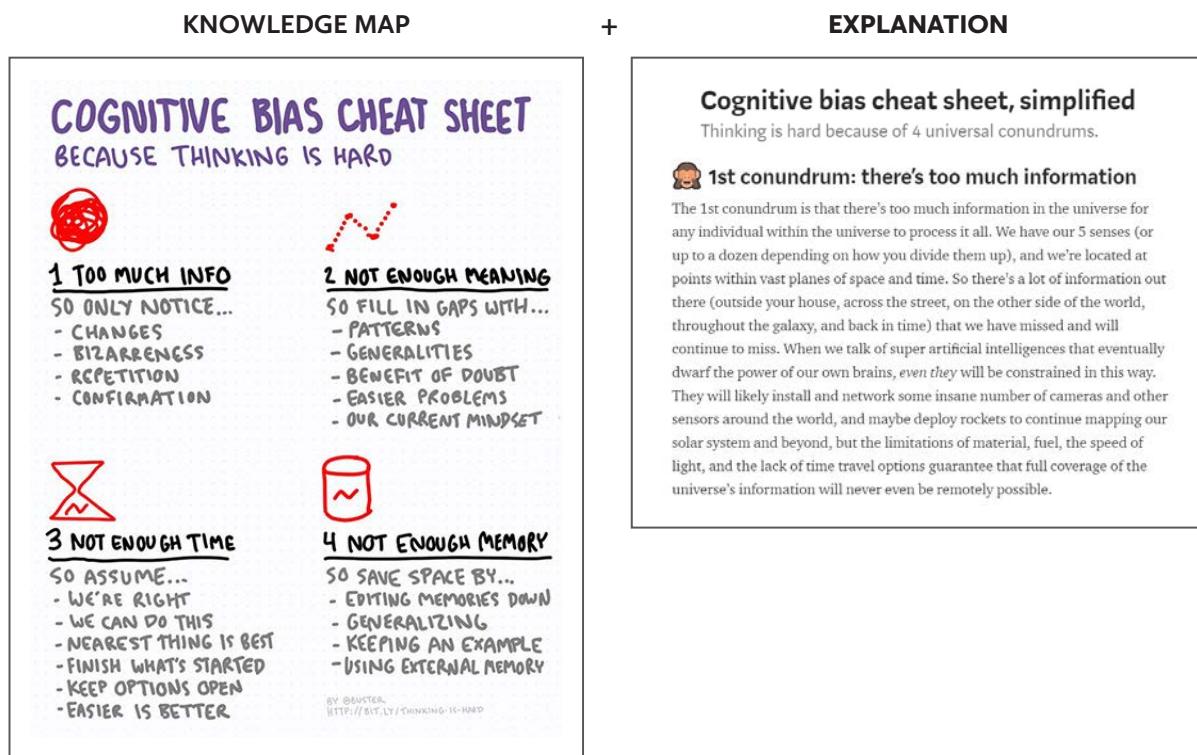


4 NOT ENOUGH MEMORY

- SO SAVE SPACE BY...
- EDITING MEMORIES DOWN
 - GENERALIZING
 - KEEPING AN EXAMPLE
 - USING EXTERNAL MEMORY

BY @BUSTER
[HTTP://BIT.LY/THINKING-IS-HARD](http://bit.ly/thinking-is-hard)

In effect, this was him zooming out to provide a summary for a higher knowledge level to help those who either didn't want all the detail of the original article or who wanted a bigger picture overview before descending into the detail.



However, there is also potentially a missing level below the original map as some people might want more detail on the individual cognitive biases within each cognitive tendency.

As an example of what this might look like, on the next page is a table I've created for the "We notice when something has changed" cognitive tendency with short summary descriptions of each bias. Longer written explanations for each of the biases could also be provided.

Cognitive tendencies from the Cognitive Bias Codex

Problem 1: There's too much information

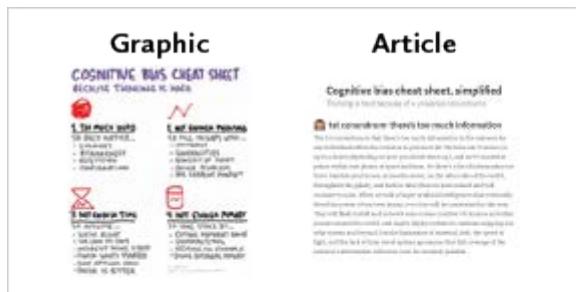
Cognitive tendency 1-3: We notice when something has changed

| COGNITIVE BIAS | DESCRIPTION |
|-------------------|---|
| ANCHORING | The tendency to rely too heavily, or “anchor”, on one trait or piece of information when making decisions (usually the first piece of information acquired on that subject) |
| CONSERVATISM | The tendency to revise one’s belief insufficiently when presented with new evidence |
| CONTRAST EFFECT | The enhancement or reduction of a certain stimulus’ perception when compared with a recently observed, contrasting object |
| DISTINCTION BIAS | The tendency to view two options as more dissimilar when evaluating them simultaneously than when evaluating them separately |
| FOCUSING EFFECT | The tendency to place too much importance on one aspect of an event |
| FRAMING EFFECT | Drawing different conclusions from the same information, depending on how that information is presented |
| MONEY ILLUSION | The tendency to concentrate on the nominal value (face value) of money rather than its value in terms of purchasing power |
| WEBER-FECHNER LAW | Difficulty in comparing small differences in large quantities |

The categorisation above has been taken from Buster Benson’s work on the Cognitive Bias Codex. See <https://betterhumans.coach.me/cognitive-bias-cheat-sheet-55a472476b18> and <https://medium.com/thinking-is-hard/4-conundrums-of-intelligence-2ab78d90740f>.

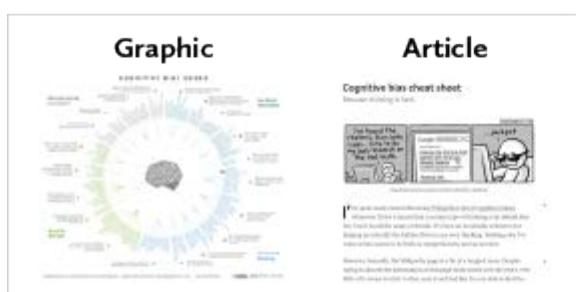
The descriptions of the cognitive biases have been taken from the Wikipedia list of cognitive biases at https://en.wikipedia.org/wiki/List_of_cognitive_biases.

The graphic below shows the move up to a higher level of detail that Benson made with his second article as well as the move down to a more detailed level that could also have been made.



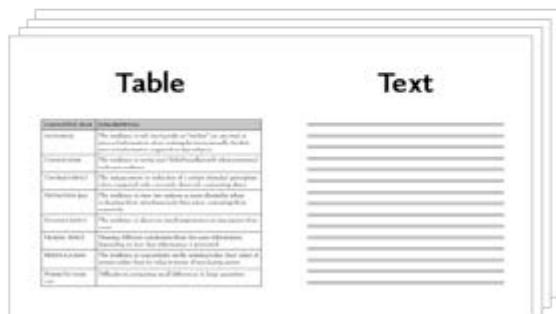
Level +1 Zoom out

Buster Benson then produced a summary that focused just on the four problem areas and the 20 cognitive bias categories.



Level 0 Original level of detail

The initial article and graphic showed that 189 cognitive biases could be categorised into four different problem areas and 20 cognitive bias categories.



Level -1 Zoom in

There could also be a more detailed level that, for each cognitive bias category, provided a table with short descriptions together with longer explanations of each cognitive bias.

Of course, the number of levels provided is a decision for the content creator as it's always possible to create a number of extra higher levels showing more of the bigger picture and the wider context as well as extra lower levels providing more detail.

Missing levels in other knowledge maps

We can also look at some of the other knowledge maps in terms of potentially missing levels.

Both the Big History Timeline Wallbook and Richard Watson's Megatrends and Technologies map include an incredible amount of detail. This isn't necessarily a problem as part of their power and value comes from having such a huge quantity of information collected together in one place. This allows people to understand the big picture and identify new connections in ways that would be impossible if the information was split up into multiple maps.

However the quantity of information presented will be overwhelming to some people. This means that it could also be helpful to provide a higher summary level which would allow reader to zoom out to focus on the bigger picture changes or trends - before returning to the original map to zoom back in for more of the detail.

Dominic Walliman's Map of Physics is a top-level description of the individual fields within physics so, on the next level of detail down, there could be individual knowledge maps for each of these fields.

The two book summaries I included in Part 1 - *All Out War* by Tim Shipman and *Deep Work* by Cal Newport - could be augmented by knowledge maps and summary explanations of all the individual chapters as well.

PART 3: MULTI-LEVEL CONTENT – FORMAT, BENEFITS AND USES

3.1 Format

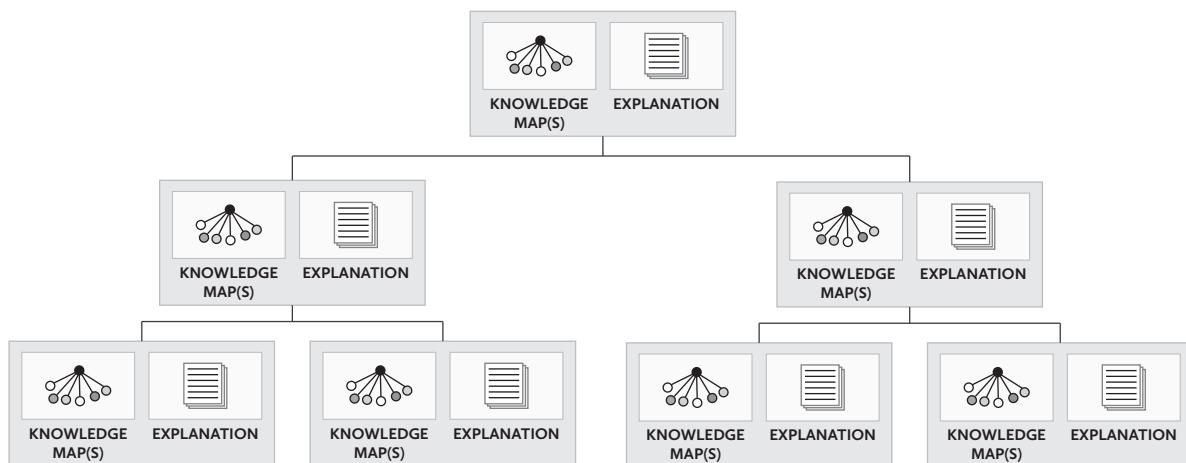
3.1.1 COMBINING KNOWLEDGE MAPS AND SUMMARIES

We saw in Part 2 how learners need the different knowledge levels differentiated to help them zoom in and out easily and I suggested that summaries of content from lower levels would help to facilitate this.

However the existence of multiple knowledge levels causes an additional problem as they make the structure of an explanation even more complicated to understand. Instead of there just being relationships between elements on one level, the existence of multiple levels means there is now a need to understand relationships both within levels and between levels.

This makes visual representations of knowledge structures even more essential as it means that there are even more relationships between knowledge elements to understand. Therefore I believe that content is made more understandable when it includes both knowledge maps showing the relationship of elements to each other and explanatory summaries. The Cognitive Bias Codex example showed how combining knowledge maps and summaries made the explanations much easier to understand.

That means we can re-state Reif's diagram of a hierarchically clustered knowledge organisation by showing each cluster with both elements.



From now on, I propose to use the term ‘multi-level content’ for hierarchically organised knowledge that includes both knowledge maps and explanation.

Before moving on, it may be helpful to re-cap two important points from Part 1:

1. Knowledge maps can describe many different knowledge structures and can be in the format of diagrams, representational graphics or a combination of both. A knowledge cluster isn't necessarily restricted to having just a single knowledge map and can include multiple ones.
2. Explanations can be written or spoken - and these explanations can be either short or long, depending on what needs to be explained and the needs of the audience. Written explanations could encompass a few paragraphs or many pages. A verbal explanation could be a few spoken sentences or a long presentation or lecture.

3.1.2 THE FORMAT OF REIF'S KNOWLEDGE CLUSTERS

While Reif doesn't go into a great deal of detail about how he envisages the format of knowledge clusters, his book provides clues that his solution would include a strong visual element.

1. In his detailed example of hierarchical knowledge organisation using the topic of basic physics, he:

- creates a diagram to illustrate the central knowledge about mechanics (ie. the three key concepts of motion, interactions and the laws of mechanics, which define the relationship between motion and interactions)¹³
- and then provides elaborations of the momentum and energy laws using the format of a table with definitions.

2. He also suggests that historical events can be described within a hierarchically organised timeline¹⁴.

3. Some of his examples of hierarchical knowledge organisation (like geographical maps and architectural design plans) are visual.

4. His book is full of diagrams.

Therefore I think he might well have been in favour of adding knowledge maps to knowledge clusters.

3.2 Benefits of multi-level content

Multi-level content provides benefits both for learners and content creators.

3.2.1 BENEFITS FOR LEARNERS

The many benefits of organising knowledge hierarchically with multi-level content include:

- helping learners to grasp the big picture of an area quickly and then allowing them to move quickly between the big picture and the detail, so they never lose their sense of where they are in a particular knowledge area (as Frederick Reif puts it, hierarchical knowledge organisation allows learners “to accommodate any amount of detailed knowledge without losing sight of the global knowledge structure”¹⁵)
- allowing learners to identify quickly the most critical information in an area without the danger of being overwhelmed by detail
- being able to quickly scan the key ideas of an area allows learners to easily decide whether that area is worth more of their time and whether they want to explore more of the detail
- making knowledge structures explicit means that learners are given clarity about the components of a topic, description or argument and how they fit together. This means that they don't have to decipher implicit knowledge structures from multiple sections of text or spoken explanation, which therefore allows more of their cognitive energy to be used on understanding, assessment and reflection

¹³ *Applying Cognitive Science to Education: Thinking and Learning in Scientific and Other Complex Domains*, Frederick Reif, MIT Press, 2010, pp.152-154

¹⁴ Reif, p.108.

¹⁵ *Applying Cognitive Science to Education: Thinking and Learning in Scientific and Other Complex Domains*, Frederick Reif, MIT Press, 2010, p.148

- multi-level content can enhance memorisation because easily accessible summaries make it easier to revise and embed ideas. Structuring information can also help memory. As Frederick Reif writes: “elaboration can facilitate retrieval because access to some central knowledge then makes it easy to access the subordinate knowledge associated with it”¹⁶.
- being provided with a coherent and understandable description of a topic or curriculum allows learners to assess how much progress they have made in a particular area and how much more knowledge they have to cover.

3.2.2 BENEFITS FOR CONTENT CREATORS

There are two main benefits for content creators.

Firstly, understanding the concept of multi-level content can help content creators to communicate more effectively so they are able to get their messages across with clarity and in an easier-to-understand format.

Secondly, I believe that the process of creating multi-level content improves one’s thinking process. Creating knowledge maps forces one to clarify the relationships between all the knowledge elements. Creating summaries of the different components helps to refine the quality of one’s argument or description. Doing both helps to identify gaps and any extra work that is needed.

3.3 Uses for multi-level content

There are five particular areas in which multi-level content could be used.

1. Non-fiction books
2. Business/organisations
3. Education
4. Maps of particular knowledge areas
5. Training courses

3.3.1 NON-FICTION BOOKS

My thinking about knowledge maps and hierarchical knowledge organisation started in part with non-fiction books and the problems that many readers seem to face.

I looked at some of the existing strategies developed to help people to read non-fiction books more effectively, such as how to identify and extract the most important ideas from a book. However, I came to realise that, while many of these strategies do work¹⁷, there will only ever be a small minority of readers who have the motivation to learn these strategies and put them into practice.

It would actually be much more helpful for readers if more non-fiction authors were to produce multi-level content with knowledge maps and hierarchically organised content.

¹⁶ Reif, p.143

¹⁷ Richard Koch has written an excellent blog post on using the 80/20 principle to read a non-fiction book - <http://richardkoch.net/2018/05/the-80-20-way-to-read-a-non-fiction-book>.

Some problems that non-fiction readers face

Here are some of the problems that readers report that they have when reading non-fiction books.

1. GETTING STARTED WITH A BOOK

1.1 Finding it hard to get started. We all know the experience of enthusiastically buying a book and then having it stand unopened on a bookshelf for months, years or even for ever. Being confronted with hundreds of pages of text combined with the knowledge that they will take many hours to get through can make it hard to get started.

2. GIVING UP ON A BOOK

2.1 Losing interest. Many books are not finished because readers lose interest. A common experience is eagerly starting a book and then running out of momentum in the midst of Chapter 1 or 2.

3. PROBLEMS WHEN READING A BOOK

3.1 Lack of a big picture. When books don't have a clear structure or summaries of the main points, it's easy for readers to get confused as they start drowning in too much detail and losing sight of what the key ideas are and how they relate to each other.

3.2 Being overwhelmed by too much detail. By not providing different levels of detail, most authors must assume that the level of detail they give is the level of detail all readers want. However some readers will want less detail because they don't have the time or the need for the most detailed level of explanation. Alternatively they may need less detail initially in order to get interested in the book and only then will they require more detail.

3.3 Returning to a book after a break.

It's easy to forget the thread of a book's argument after putting it down for a few days or weeks. Readers then either have to carry on reading superficially without remembering the outline of the book's argument or spend time struggling to identify the key ideas from the pages they have already read.

4. PROBLEMS AFTER FINISHING A BOOK

4.1 Forgetting a book's ideas. Many readers complain about how little they remember of a book's ideas even after they have spent hours reading it. That's to be expected. Cognitive psychology shows how easily facts and ideas are forgotten. It is difficult to review the ideas in a book without taking time-consuming notes which most readers don't seem to have either the time or the motivation to do.

4.2 Struggling to work out what action to take. Many books suggest new behaviours and strategies for the reader. If these strategies and behaviours aren't summarised adequately, it's easy for a reader to move on to the next book without having taken any action on the previous one.

4.3 Returning to a book. When readers want to remind themselves of the ideas in a book they have read in the past, a detailed re-read is often needed in order to get to grips with the book again.

Applying multi-level content to non-fiction books

Most non-fiction books will have three levels of detail:

- a big picture level for the ideas in the book as a whole
- a big picture level for the ideas in each individual chapter
- the detailed content in each individual chapter.

If we wanted to provide multi-level content that differentiated the content on each of these levels, we could have:

- a book summary with a knowledge map and explanatory text for the book as a whole
- chapter summaries with knowledge maps and explanatory text for each individual chapter
- the contents of individual chapters with text combined with diagrams, tables and representational graphics.

A diagram showing this structure can be seen on the next page.

However depending on the content of the book and how it is organised, other configurations are possible.

There are two scenarios in which there could be four levels of detail:

1. if a book is divided into parts and then chapters, the four levels would be:

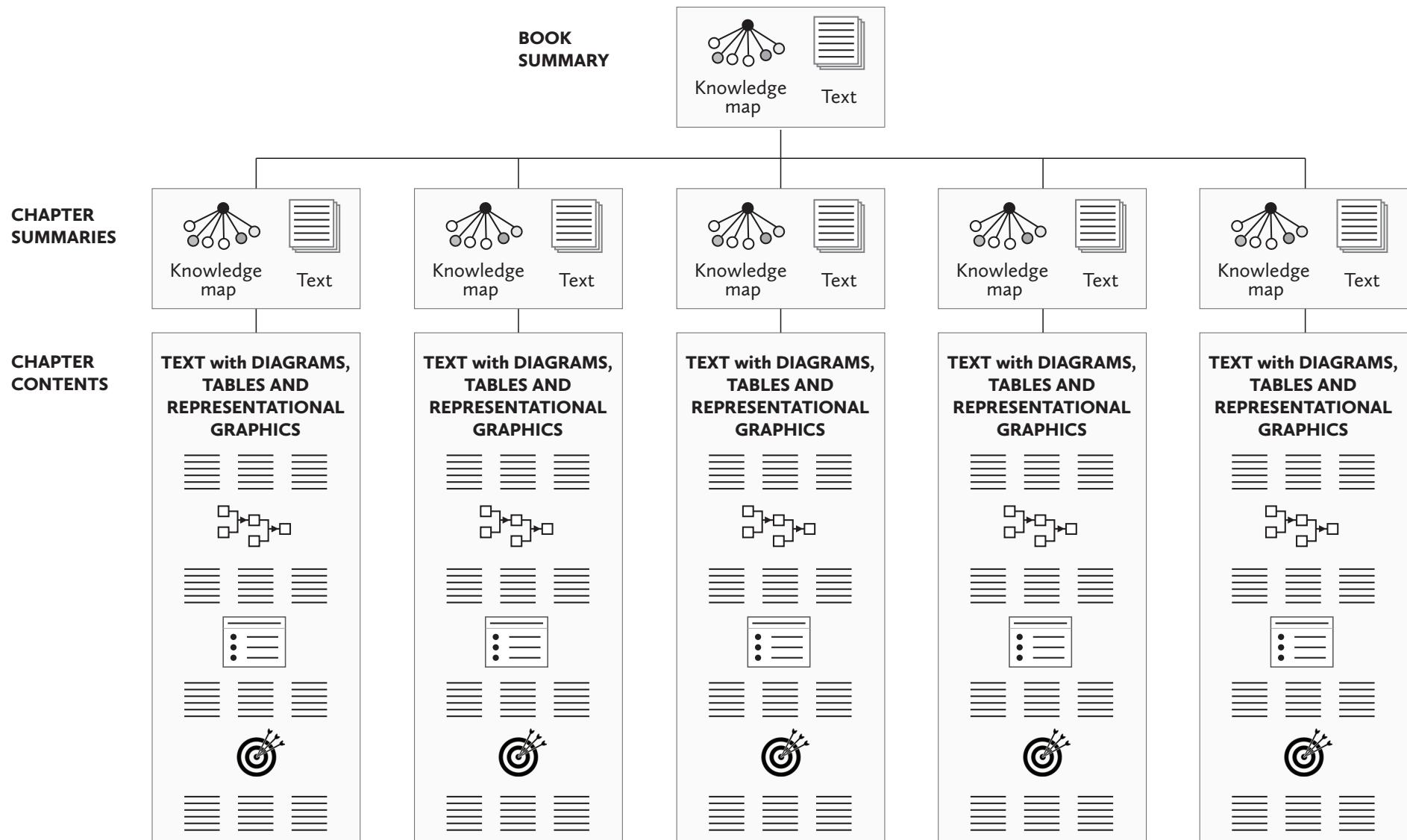
- the book summary
- different part summaries
- different chapter summaries
- the contents of individual chapters

2. secondly, if a book is divided in chapters and then chapter sections, the four levels would be:

- the book summary
- the chapter summaries
- the chapter section summaries
- the contents of individual chapter sections.

EXCLUSIONS

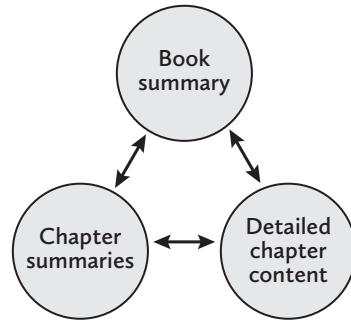
Multi-level content isn't appropriate for non-fiction books that have a strong narrative component and where knowing the big picture before starting a detailed read would ruin the surprise of the ending.



The format of a non-fiction book with multi-level content

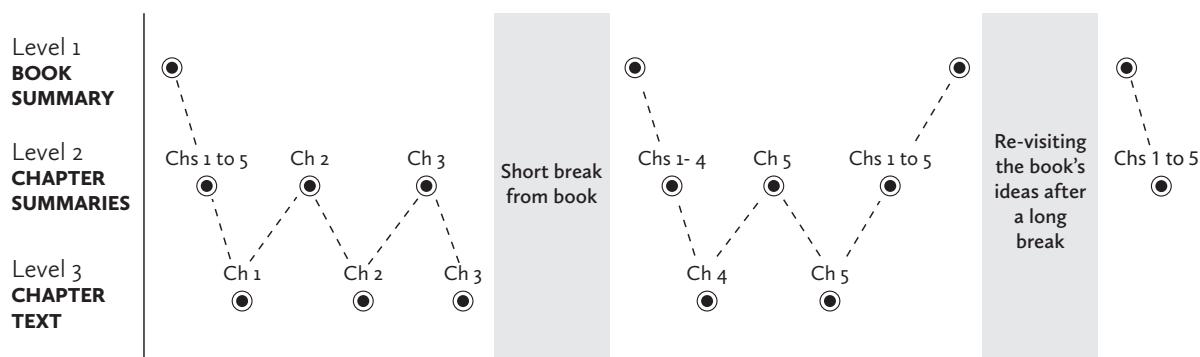
Reading a book with multi-level content

Having a structure of a book summary, chapter summaries and detailed chapter text would allow readers to cycle between the different levels of detail to suit their needs.



The graphic below shows the progression a reader might make through a book of five chapters organised with multi-level content.

1. Start with a review of the whole book summary, looking at the knowledge map and explanation, getting an idea about what the book is about as a whole and how it is structured.
2. Move on to a review of all the chapter summaries to get an idea of what all the individual chapters are about in more detail.
3. Read the text of Chapter 1.
4. Read the summary and text of Chapter 2 and then Chapter 3.
5. After getting interrupted and having to take a long break from the book, refresh one's memory by re-reading the whole book summary and the summaries of Chapters 1, 2 and 3.
6. Carry on with the book by reading the summary and text of Chapter 4 and then Chapter 5.
7. Before reflecting on the book as a whole, re-read the book and chapter summaries.
8. If, after finishing the book, the reader wants to refresh their memory of the topic some time after, they can revisit the ideas by reading the whole book and chapter summaries without needing to re-read the book again.



A timeline for reading a book with multi-level content

Who benefits?

There are two groups of people who would benefit from the wider provision of multi-level content in non-fiction books: readers as well as authors who are particularly keen to communicate their ideas.

1. Readers

1.1 GETTING STARTED WITH A BOOK

1.1 Finding it hard to get started

PROBLEM: being confronted with hundreds of pages of text that will take many hours to get through can make it hard to get started.

SOLUTION: the 20 minutes or so needed to read the book and chapter summaries provides an easy way in to starting a book.

2. GIVING UP ON A BOOK

2.1 Losing interest

PROBLEM: many books are not finished because readers lose interest. A common experience is enthusiastically starting a book and then running out of momentum in the middle of Chapter 1 or 2.

SOLUTION: the summaries allow readers to be much clearer about whether the book is going to be worth reading in full and to quickly identify which chapters of the book they are going to find most interesting. In addition, even if they only spend 20 minutes on a book, they will have got the big picture of the book and read the main arguments – in the same time that a reader not having access to multi-level content would take to get bogged down in the middle of Chapter 1 and give up.

3. PROBLEMS WHEN READING A BOOK

3.1 Lack of a big picture.

PROBLEM: when books don't have a clear structure or summaries of the main points, it's easy for readers to get confused as they end up drowning in too much detail and losing sight of the key ideas and how they relate to each other.

SOLUTION: multi-level content gives readers the flexibility to choose between detail and context. When they want to focus on detail, they can zoom in to find it in the text. When they're getting confused,

they can zoom out using the summaries and knowledge maps to understand where that detail fits into the big picture.

3.2 Being overwhelmed by too much detail

PROBLEM: by not providing different levels of detail, most authors must assume that the level of detail they give is the level of detail all readers want. However some readers will want less detail because they don't have the time or the need for the most detailed level of explanation. Alternatively they may need less detail initially in order to get interested in the book and only then will they require more detail.

SOLUTION: multi-level content allows readers to focus in on the level of detail they find most helpful.

3.3 Returning to a book after a break

PROBLEM: it's easy to forget the thread of a book's argument after putting it down for a few days or a few weeks. Readers then either have to carry on reading superficially without remembering the outline of the book's argument or spend time struggling to identify the key ideas from the pages they have already read.

SOLUTION: multi-level content allows readers to quickly refresh their memories about what they have previously read. That means that they can easily pick up the thread of the book's argument and therefore carry on reading productively.

4. PROBLEMS AFTER FINISHING A BOOK

4.1 Forgetting a book's ideas.

PROBLEM: many readers complain about how little they remember of a book's ideas even after they have spent hours reading it. That's to be expected. Cognitive psychology explains how easily facts and ideas are forgotten.

SOLUTION: when readers come across ideas they want to embed in their memory, multi-level content allows readers to revisit key ideas and work on embedding them in their memory. In addition, having clear explanations of how the detail fits into the big picture can make the book's ideas more memorable.

4.2 Struggling to work out what action to take

PROBLEM: many books suggest new behaviours and strategies for the reader. If these new strategies and behaviours aren't summarised adequately, it's easy for a reader to move on to the next book without taking any action.

SOLUTION: having adequate summaries allow readers to easily revisit the recommended strategies and behaviours once they have finished a book and then decide which, if any, they are going to put into practice.

4.3 Returning to a book

PROBLEM: when readers want to remind themselves of the ideas in a book they have read in the past, a detailed re-read is often needed in order to get to grips with the book again.

SOLUTION: multi-level content means that readers can get an overview of the whole book in about 20 minutes.

2. Authors

The second group who would benefit from multi-level content are non-fiction authors who have a particular interest in communicating their ideas to their readers.

Into this category would come authors who want their readers to:

- change how they think about or experience the world
- take a particular action eg. support a policy, vote for a political party, implement a business strategy, or follow a self-help programme
- talk about the author's ideas and persuade other people to read their book so the author's ideas can start to go viral.

It is in the interest of all these authors to reduce as much as possible the friction involved in consuming and taking on board their ideas.

Unfortunately, as I described in the *Problems with non-fiction books* section, the current format of non-fiction books imposes a huge level of friction on readers, which is not necessary.

If you are an author with important ideas to communicate to your audience, is it more sensible to:

- a) require readers to spend four to six precious hours of their life on reading your book with a content format which means that many may not even start let alone finish your book? or
- b) provide them with multi-level content that delivers summaries of the whole book and individual chapters as well as all the necessary detail so that:
 - readers can read a quick overview of your main ideas which can increase their interest so they become more motivated to read the whole book
 - they are provided with an explicit conceptual framework which frees up the mental energy that would have been spent on decoding that structure so that their mental energy can be used for the more important tasks of understanding, assessment and reflection

- readers can zoom out to the big picture when they are feeling stuck or when they return to the book after a break, which means that they are less likely to get bogged down in detail or lose the thread of your argument
- they can review the book's main ideas more easily when they have finished the book which allows them to explain your ideas more effectively to other people?

Reports

A related use of multi-level content is for reports. People often struggle with text-heavy reports where the structure can hard to discern and going through it can soak up a great deal of time.

Reports with multi-level content should be easier to read and will allow readers to engage with the content at the level of detail of their choice.

3.2 Businesses and organisations

There are different ways that businesses and organisations could use multi-level content:

i) Richard Watson, the creator of the Megatrends and Technologies map, has spoken in a talk of how the future planning departments of various companies are using his map as a framework for discussing possible future social and technological changes and how their company needs to react to them.

However many companies and organisations could also find it profitable to develop their own megatrends map focusing on changes that may be coming to their own industry or field. It wouldn't necessarily have to be as detailed as Richard Watson's map.

Such a map and accompanying explanation could spark discussion and creativity in a more effective way than a text-heavy trends document.

ii) maps and explanations can also be used to explain current strategies to staff and to provide an easily understood framework within which ongoing decisions can be made.

iii) another use is for explaining the strategies or activities of a company or organisation to external groups.

While the scale of Richard Watson's map conveys a very powerful impression, I think most businesses and organisations would benefit from developing maps with multiple knowledge levels. This allows audiences to navigate more easily between the big picture and the detail, and reduces the possibility of overwhelming them with too much information.

3.3 EDUCATION

I'm not involved in the education field so the following ideas are put forward tentatively. I would be interested to discuss with teachers and others how knowledge maps, hierarchical knowledge organization and multi-level content can be used in education.

Frederick Reif

Frederick Reif is primarily concerned with education as the title of his book *Applying Cognitive Science to Education* suggests.

He is passionate about the importance of organising knowledge in education, as can be seen from the following quotes:

“Poorly organized knowledge cannot readily be remembered or used. But students often don't know how to organize their knowledge effectively and don't realize that learning can be greatly facilitated by good knowledge organization. Hence instructional efforts need to focus more deliberate attention on the organization of students' acquired knowledge.”¹⁸

“Most instructors or textbooks pay much more attention to the content of conveyed knowledge than to its organisation. Even when knowledge is locally well organised in a lecture or chapter, there is little effort to organize the entire knowledge globally. Thus the task of organizing a student's *entire* acquired knowledge is left largely to the student. This is often a rather difficult task. (Even highly experienced individuals may find it difficult to organize a complex body of knowledge in a coherent and easily remembered form.) The net result is that many students' acquired knowledge often remains poorly organized.”¹⁹

¹⁸ *Applying Cognitive Science to Education: Thinking and Learning in Scientific and Other Complex Domains*, Frederick Reif, MIT Press, 2010, pp.137-138

¹⁹ Reif, p.157

He concludes at the end of his chapter on *Organizing Knowledge*:

“As much attention must be paid to the organization of knowledge as to its content. When trying to convey a body of knowledge, teachers should attempt to develop explicitly, and then gradually expand, a well-organized knowledge structure that students can actively use.”²⁰

Knowledge maps in education

The knowledge maps specifically designed for pupils or students that I discussed in Part I show that an increasing number of educators understand the importance of organising knowledge in a visual way.

These were:

- the Big History Timeline Wallbook
- the Linguisticator language maps
- the Map of Physics
- the map of Hitler’s rise
- the map of literary periods in English literature.

Knowledge organisers

Recently there has been a growth of interest in knowledge organisers, which are single pages that detail, in [Joe Kirby's words](#), “the exact facts, dates, events, characters, concepts and precise definitions that all pupils are expected to master in long-term memory”.

However there has been discussion about whether they focus too much on the learning of facts rather than on learning how facts are connected.

Ben Newmark, the history teacher whose map of Hitler’s rise I discussed in Part I, has [written about](#) his concern about history knowledge organisers which are:

“lists of random facts based on existing, flawed curriculums. We, as a profession, may be in danger of fetishising the simple memorisation of content as a virtue in itself. The quality of a child’s history education is dependent not only on knowing lots of stuff, but also knowing stuff that connects together to form meaningful schemas. Failing to do this could result in history in schools becoming nothing more than revision for a pub quiz that will never happen.”

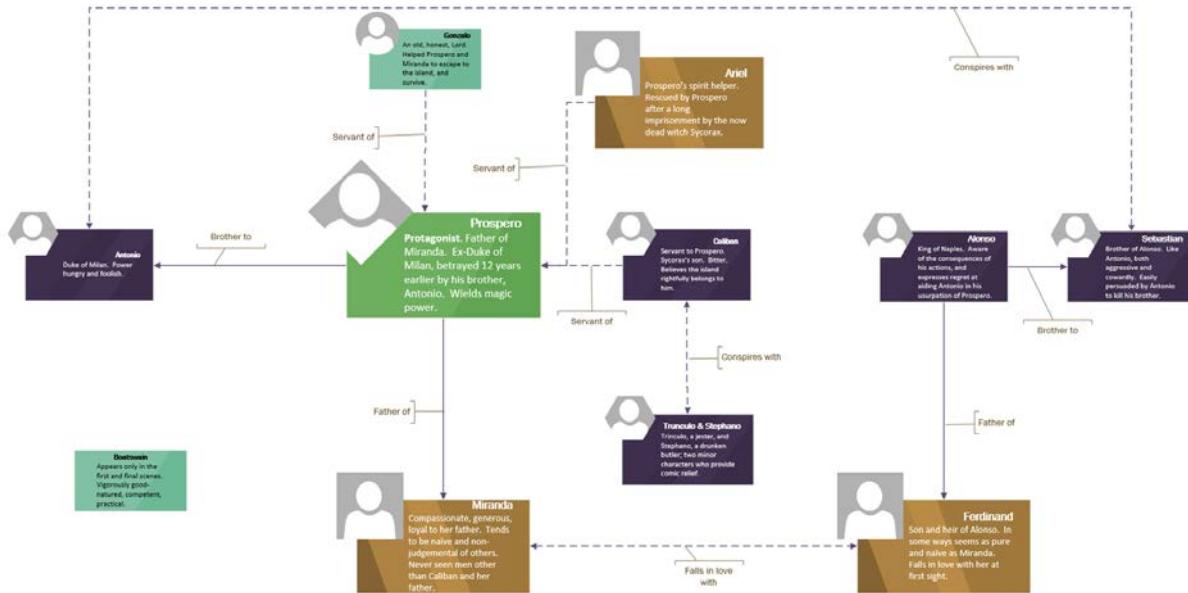
Kristopher Boulton on knowledge organisation

In a [blog post](#) on Knowledge Organisation influenced by Frederick Reif’s ideas, educator Kristopher Boulton wonders whether “whether knowledge organisers are just the first step in a greater journey of expanding our understanding of knowledge organisation more broadly”.

Using the example of the characters in The Tempest, he is concerned that showing pupils a list of facts about the characters doesn’t make it easy for them to construct a schema of how the characters relate to each other.

Instead he thinks that it would be more beneficial to provide a diagram that shows the relationships visually. “Ultimately”, he writes, “this is the mental schema we would want pupils to construct in their own mind; by laying it out transparently we guarantee success for everyone.”

²⁰ Reif, p.160



Reduced version of Kristopher Boulton's diagram showing the relationships between the characters in The Tempest

He concludes the blog post by suggesting that providing visual explanation in addition to tables of facts “could increase the probability of a given child’s speed in committing facts to memory, the storage strength and enduring retrieval strength of those facts, and their knowledge of the relationships between the facts”.

Using hierarchical knowledge organisation with knowledge organisers

The following thoughts about how to organise knowledge about Macbeth and modern German history both visually and hierarchically were stimulated by Kristopher's blog post.

I want to start by mentioning two key principles:

- i. It is important to highlight Frederick Reif's observation that, while the overall knowledge organisation should be hierarchical, there doesn't have to be a hierarchical structure within each knowledge cluster²¹.

In Part I of this paper, I described some of the different knowledge structures that exist, including causal explanations, timelines, procedural steps and stories.

2. Knowledge organisers should include both knowledge maps (showing structural relationships) as well as written explanations. As Kristopher Boulton showed, the problem many knowledge organisers have at the moment is that they focus just on the written detail.

I agree with him that the best option is to combine a format based on written detail with formats that show more of the structural relationships between ideas, concepts and facts.

The former allow pupils to more easily learn key factual knowledge while the latter can allow them to develop their understanding of important relationships and to show them the context into which the facts they have learnt fit.

²¹ *Applying Cognitive Science to Education: Thinking and Learning in Scientific and Other Complex Domains*, Frederick Reif, MIT Press, 2010, p146.

Examples

Here are two examples showing how knowledge organisers might be organised:

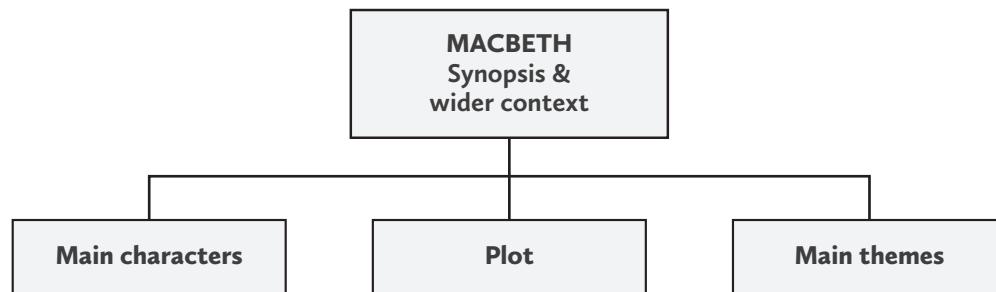
- (i) Shakespeare's play Macbeth
- (ii) Modern German history.

Please ignore any errors or misconceptions about *Macbeth* or German history that have crept in. The idea is just to provide illustrations of the concept.

MACBETH

Here is what the structure of a very simple knowledge organiser for Macbeth, incorporating both knowledge maps and explanation, might look like.

On the top level is a synopsis of the play and some wider context about William Shakespeare. On the second level can be found the more detailed topics looking at the main characters, the plot and the main themes.



SYNOPSIS AND WIDER CONTEXT

There are various ways of representing the top level of a knowledge organiser which can be used individually or as a combination. They include:

- providing summaries of the content of lower levels
- showing how the lower levels connect
- providing more general information about the topic
- providing information about the wider context.

In the example I have created, I have provided a short synopsis of the play together with more information about William Shakespeare.

MACBETH: SYNOPSIS & WIDER CONTEXT

SYNOPSIS

A brave Scottish general named Macbeth receives a prophecy from a trio of witches that one day he will become King of Scotland.

Consumed by ambition and spurred to action by his wife, Macbeth murders King Duncan and takes the Scottish throne for himself. He is then wracked with guilt and paranoia.

Forced to commit more and more murders to protect himself from enmity and suspicion, he soon becomes a tyrannical ruler.

The bloodbath and consequent civil war swiftly take Macbeth and Lady Macbeth into the realms of madness and death.

From <https://en.wikipedia.org/wiki/Macbeth>

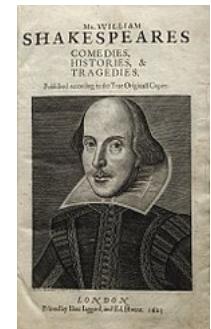
WILLIAM SHAKESPEARE

William Shakespeare, the son of a wool dealer, was born and raised in Stratford-upon-Avon in Warwickshire. He was an actor, playwright, poet, and theatre company manager in London. He wrote at least 37 plays and 154 sonnets.

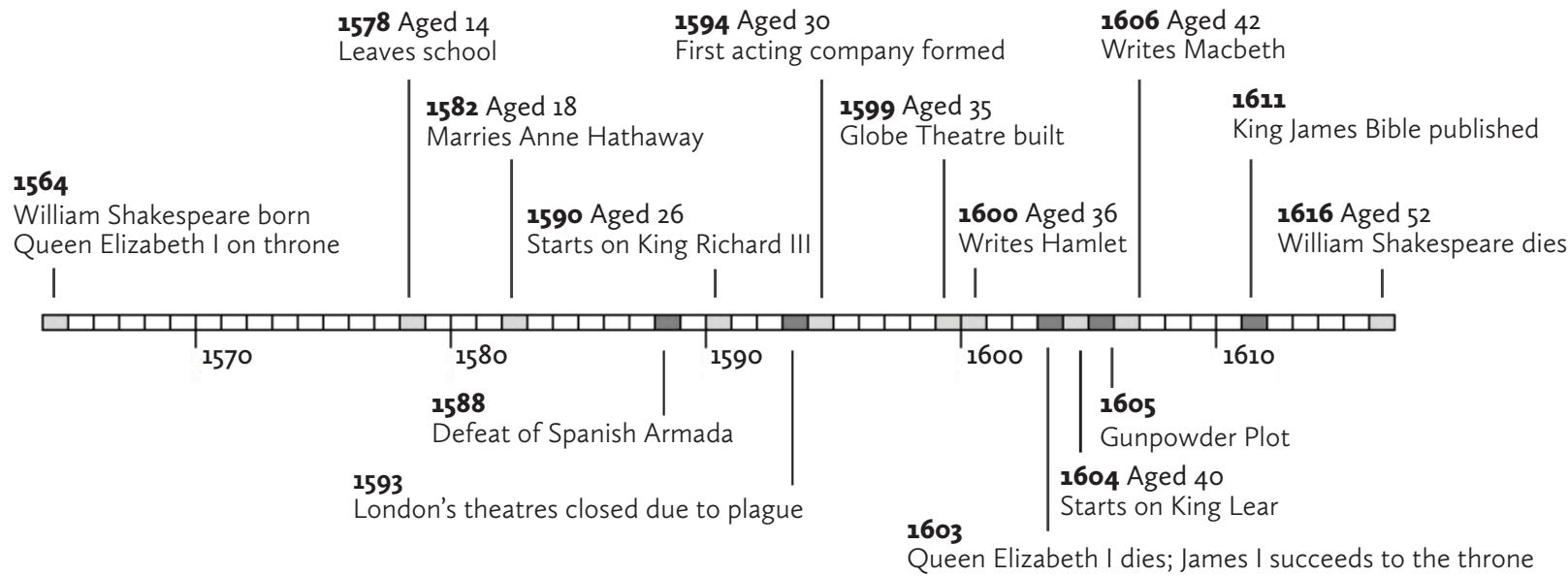
He is considered one of England's greatest ever writers who has had an unparalleled impact on both English literature and European drama. His plays have been performed more times than those of any other playwright.

At age 18 he married Anne Hathaway, who was 26 and had three children with her. He moved back to Stratford from London and died there in 1616 at the age of 52.

Some detail from https://en.wikipedia.org/wiki/Shakespeare%27s_life



TIMELINE OF SHAKESPEARE'S LIFE



MACBETH: SYNOPSIS & WIDER CONTEXT

SHAKESPEARE'S INFLUENCE

Shakespeare's work has made a lasting impression on theatre and literature. In particular, he expanded the dramatic potential of characterisation, plot, language, and genre. Until Romeo and Juliet, for example, romance had not been viewed as a worthy topic for tragedy. Soliloquies had been used mainly to convey information about characters or events, but Shakespeare used them to explore characters' minds.

His work influenced later poetry as well as novelists such as Thomas Hardy, William Faulkner, and Charles Dickens. The American novelist Herman Melville's soliloquies owe much to Shakespeare; his Captain Ahab in *Moby-Dick* is a classic tragic hero, inspired by King Lear.

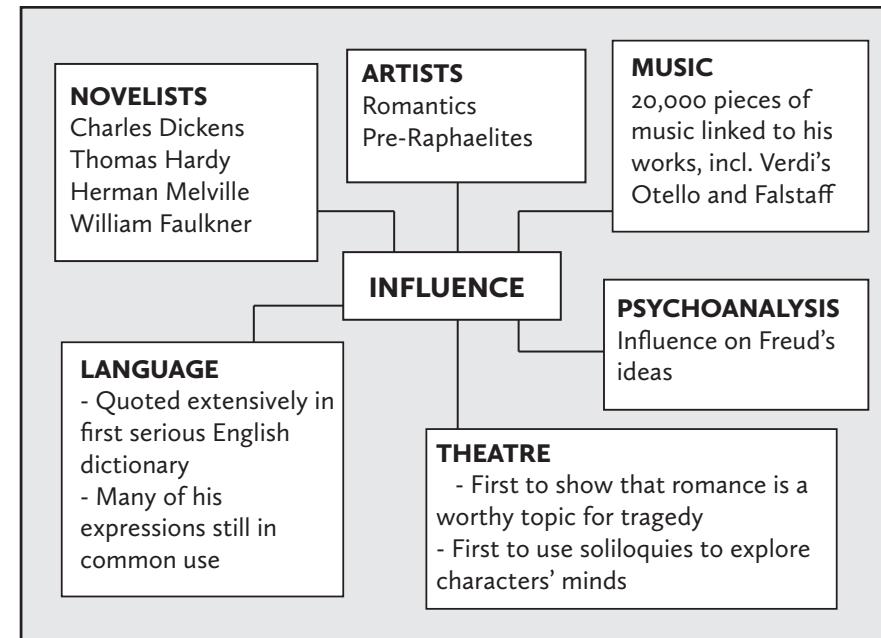
Scholars have identified 20,000 pieces of music linked to Shakespeare's works. These include two operas by Giuseppe Verdi, *Otello* and *Falstaff*, whose critical standing compares with that of the source plays. Shakespeare has also inspired many painters, including the Romantics and the Pre-Raphaelites.

The psychoanalyst Sigmund Freud drew on Shakespearean psychology, in particular, that of Hamlet, for his theories of human nature.

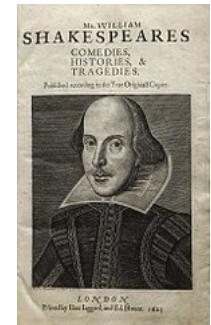
In Shakespeare's day, English grammar, spelling, and pronunciation were less standardised than they are now, and his use of language helped shape modern English. Samuel Johnson quoted him more often than any other author in his *A Dictionary of the English Language*, the first serious work of its type.

Many of his expressions such as "with bated breath" (*Merchant of Venice*) and "a foregone conclusion" (*Othello*) have found their way into everyday English speech.

Edited from https://en.wikipedia.org/wiki/Shakespeare%27s_influence



Shakespeare's influence



FLATTERING THE KING

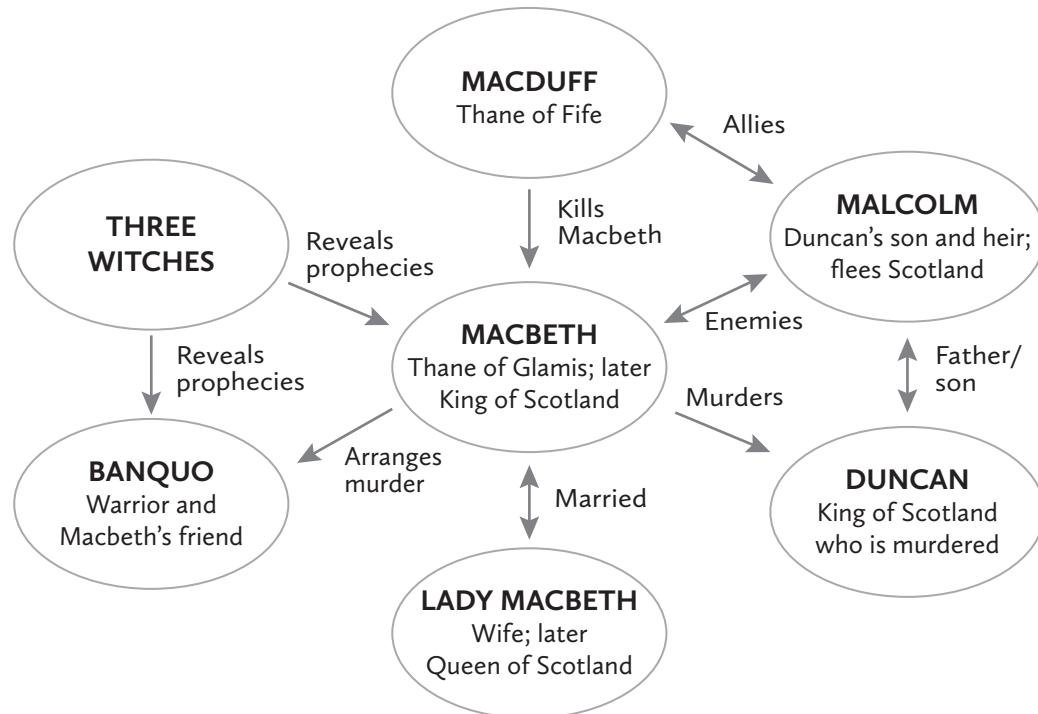
Shakespeare talked up the role of Banquo in the play in order to flatter the reigning King, James I. Banquo – the one-time friend of Macbeth who is murdered by him, but later returns to haunt Macbeth at the dinner-table – was made an important character in the play because King James I of England (James VI of Scotland), who had come to the throne a few years before Shakespeare wrote the play, claimed descent from Banquo. In Shakespeare's play, Banquo is the man who the Witches prophesy will 'get [i.e. sire] kings', even though Banquo himself will not be King.

From <https://interestingliterature.com/2015/10/06/five-fascinating-facts-about-macbeth/>

MAIN CHARACTERS DESCRIPTION

The description shows a map of the relationships between the main characters as well as short descriptions of the main characters.

MACBETH: MAIN CHARACTERS



MACBETH - After a supernatural prophecy, and at the urging of his wife, Lady Macbeth, he commits regicide and becomes King of Scotland. He thereafter lives in anxiety and fear, unable to rest or to trust his nobles. He leads a reign of terror until defeated by his former ally Macduff. The throne is then restored to the rightful heir, the murdered King Duncan's son, Malcolm.

LADY MACBETH - She goads her husband into committing regicide, after which she becomes queen of Scotland. Later, however, she suffers pangs of guilt for her part in the crime, which drives her to sleepwalk. She dies off-stage in the last act, an apparent suicide.

DUNCAN - As King of Scotland, he is the victim of a well-plotted regicide in a power grab by his trusted captain Macbeth. He is the father of two youthful sons (Malcolm and Donalbain).

MALCOLM - As the elder son of Duncan, he is heir to the throne. He eventually regains the throne after mustering support to overthrow Macbeth.

BANQUO - He is at first an ally to Macbeth (both are generals in the King's army) and they meet the Three Witches together. After prophesying that Macbeth will become king, the witches tell Banquo that he will not be king himself, but that his descendants will be. Later, Macbeth in his lust for power sees Banquo as a threat and has him murdered.

MACDUFF - Thane of Fife, he plays a pivotal role in the play: he suspects Macbeth of regicide and eventually kills Macbeth in the final act.

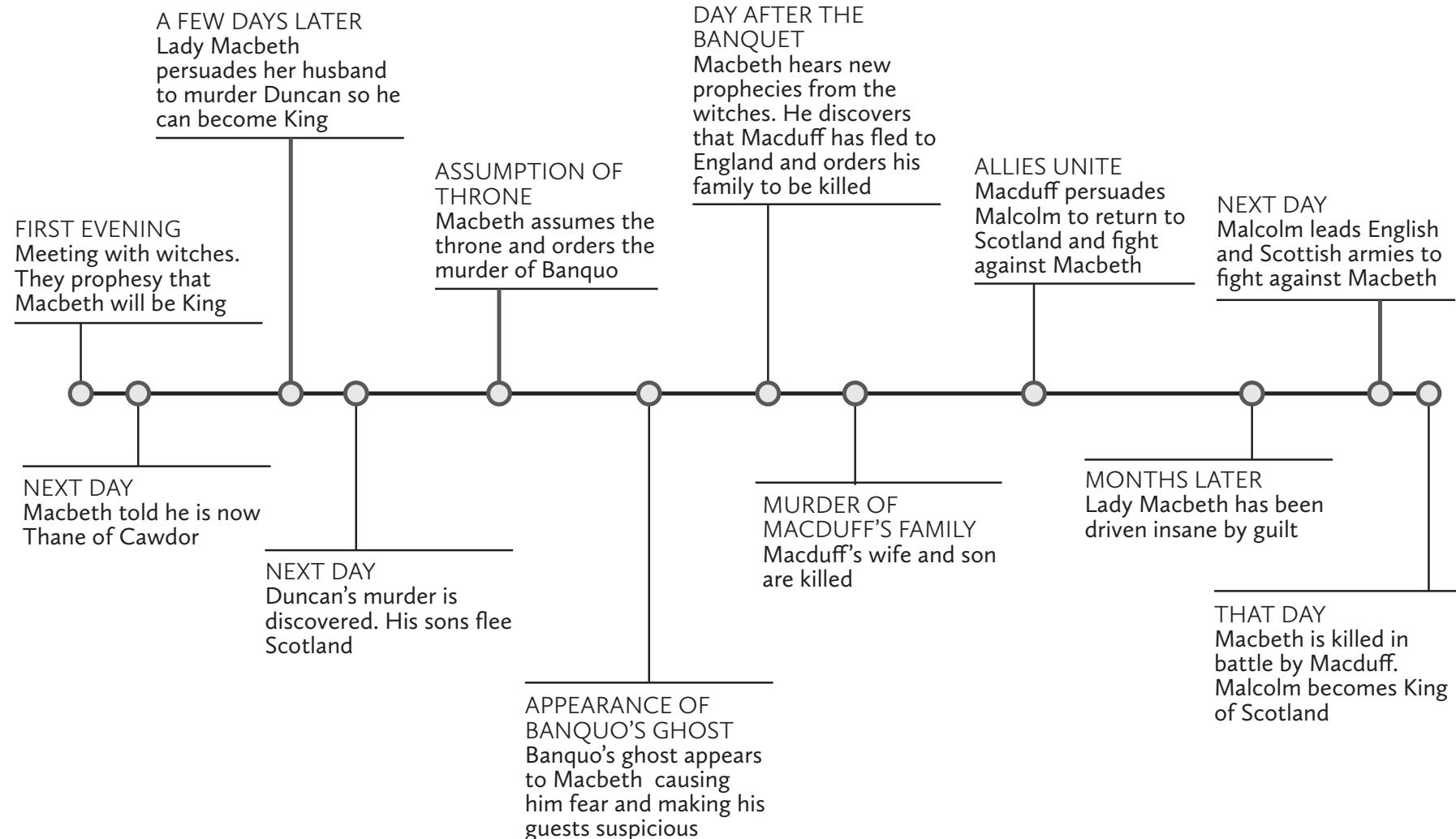
THREE WITCHES - They prophesy Macbeth's ascent to the kingship. Upon killing the king and gaining the throne of Scotland, Macbeth hears them ambiguously predict his eventual downfall.

Character descriptions from Wikipedia:

[https://en.wikipedia.org/wiki/Macbeth_\(character\)](https://en.wikipedia.org/wiki/Macbeth_(character))
https://en.wikipedia.org/wiki/Lady_Macbeth |
https://en.wikipedia.org/wiki/King_Duncan
[https://en.wikipedia.org/wiki/Malcolm_\(Macbeth\)](https://en.wikipedia.org/wiki/Malcolm_(Macbeth))
<https://en.wikipedia.org/wiki/Banquo>
[https://en.wikipedia.org/wiki/Macduff_\(Macbeth\)](https://en.wikipedia.org/wiki/Macduff_(Macbeth))
https://en.wikipedia.org/wiki/Three_Witches

PLOT DESCRIPTION

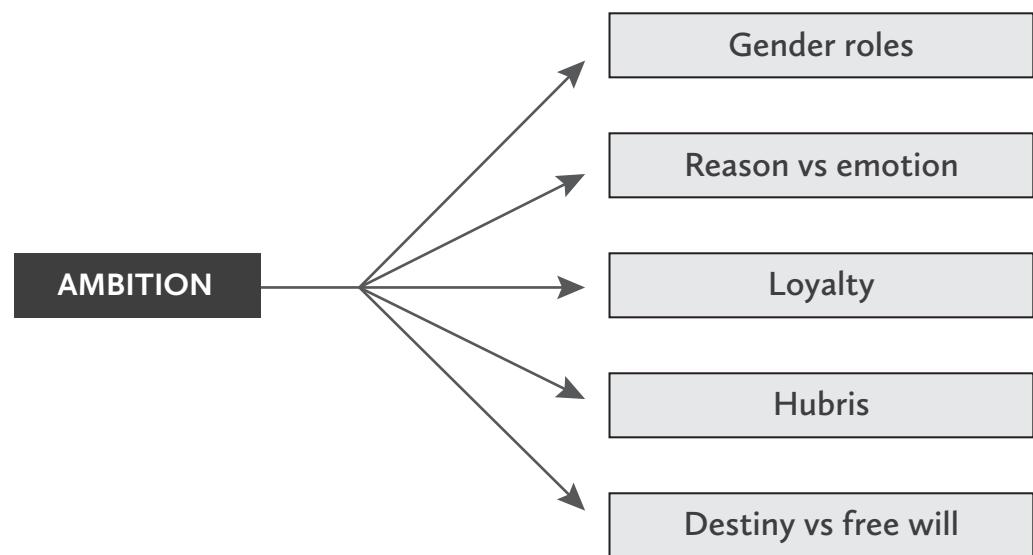
MACBETH: PLOT TIMELINE



MAIN THEMES

This description of the main themes of the play isn't exhaustive but just aims to give an example of what can be done.

MACBETH: MAIN THEMES



Using ambition as the driving force of the play allows Shakespeare to explore many other themes

AMBITION - Ambition is the main driving force of the play. The play shows how ambition can make people act destructively and how these acts can then rebound back on to the perpetrator. Ambition led both Macbeth and Lady Macbeth to murder. The witches's prophesies started off the plan to murder Duncan. Later on, Macbeth's desire to cling on to power led to the murders of Banquo and Macduff's family.

GENDER ROLES - The play is partly an exploration of people's beliefs about gender roles and they affect behaviour. Lady Macbeth asks the spirits to "unsex" her so she can escape from what she believes are the constraints imposed by her gender and so have the strength to participate in Duncan's killing. Whenever Macbeth shows any doubt or guilt, she also criticises him for his unmanliness.

REASON VS EMOTION - Macbeth and Lady Macbeth epitomise opposing approaches to making decisions and making persuasive arguments. Macbeth focuses more on a rational analysis of potential actions and how they may play out. He understands the problematical issues of regicide in relation to his religious standing and his commitment of trust to Duncan. Lady Macbeth relies more on her feelings in deciding what to do.

LOYALTY - Those who stayed loyal to Duncan and his line get rewarded. Malcolm becomes King and Macduff can avenge his family. On the other hand, the treacherous acts of Lady Macbeth and her husband are rewarded by insanity and death.

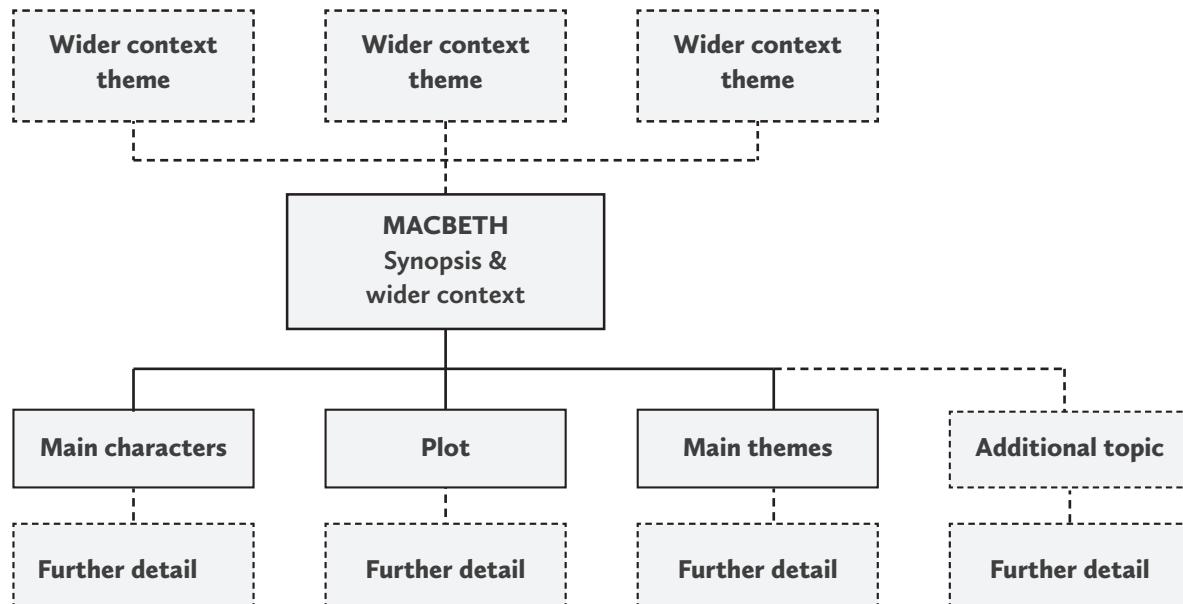
HUBRIS - The ancient Greek concept of hubris refers to the downfall of a great man like a king whose excessive pride and ambition leads to destructive behaviour and ultimately ruin.

DESTINY VS FREE WILL - The three witches provide prophecies that will all come to pass, including Macbeth's progression to Thane of Cawdor and then king. However while this might suggest that these events are just a reflection of destiny, Shakespeare shows instead that they are the result of Macbeth choosing his own fate.

EXTENDING THE MACBETH KNOWLEDGE ORGANISER

Obviously the content of any knowledge organiser will be dependent on the curriculum and what pupils need to know.

In the absence of specific curriculum details, here are some ideas about how the Macbeth knowledge organiser could be extended.



1. Additional topics. Additional topics could be added to the second level topics, such as a description of the writing style eg. Shakespeare's use of soliloquies and iambic pentameters.

2. Further detail. Each of the topics could have further detail added. For example, one could add individual timelines for each character to the Main Characters topic. These timelines could include:

- the events that happen to them
- the interactions they have with other characters
- how their motivations and emotional states change over time
- key quotes.

3. Wider context. Themes that illustrate the wider context could also be added. These could include:

- an analysis about the categorisation of Shakespeare's plays into histories, tragedies, romances and comedies
- more information about Shakespeare's life and times
- an analysis of how Shakespeare's work fits into the history of theatre.

MODERN GERMAN HISTORY

For the second example, I am going to take modern German history.

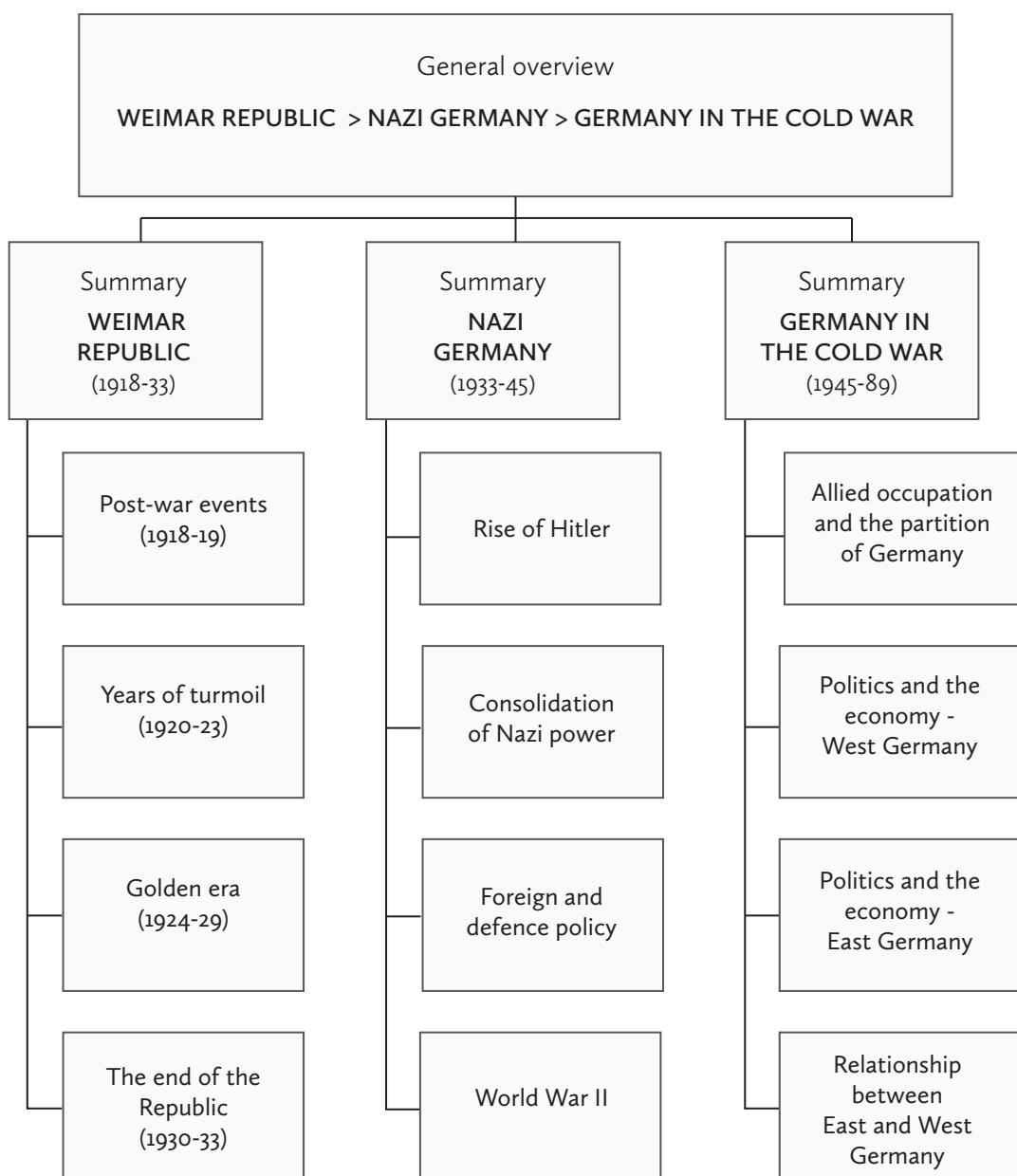
The aim of the multi-level content is to allow pupils to navigate different knowledge levels so they can move easily between the big picture and the detail, and understand how specific events fit in to a wider context.

In the graphic below, I have included three levels:

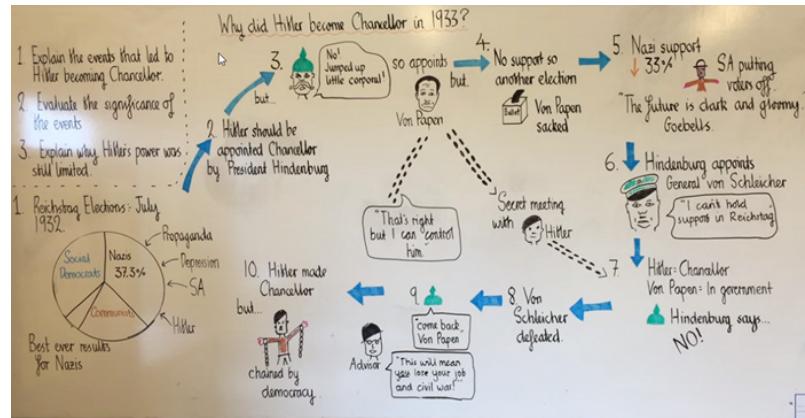
- (i) the detailed level
- (ii) the intermediate level
- (iii) the big picture level.

Units within levels (or knowledge clusters, as Frederick Reif calls them) can include:

- a knowledge map or combination of knowledge maps
- a written or spoken explanation of varying length.



(i) **Detailed level.** This level provides knowledge about specific topics, such as the Rise of Hitler which we saw Ben Newmark address earlier.



(ii) **Intermediate level.** This level is based around specific time periods. Each unit will:

- provide a summary of each of the lower level topics and show how they are related to each other
- provide information about other aspects of the time period that aren't specifically examined in the individual topics.

(iii) **General overview level.** This level will:

- provide a summary of each of the time periods
- show how each of the time periods are related to each other.

As with the Macbeth example, the number of levels will depend on the needs of the curriculum. Some specific topics like World War II are so large that they may need to be divided into sub-topics, which would create a further knowledge level at the bottom.

There could also be a further knowledge level at the top including topics such as a comparison of 20th century German history with the experience of other European countries or a longer overview of German history.

3.4 Maps of particular knowledge areas

I think hierarchically organised knowledge maps and summary explanations could prove particularly useful for people exploring new knowledge areas.

Being able to see the big picture and then to drill down into more of the detail is I think what lots of people would find helpful when learning about a new area.

I had some Alexander Technique lessons last year. It's a complex area with lots of ideas to learn and understand. Having good knowledge maps and summary explanations would have helped my understanding of the field greatly.

A friend has also discussed the possibility of creating a knowledge map and explanation to give an idea of the current state of marketing. Again that's something I think would be useful for someone trying to understand the current strands, themes and concepts of marketing and how they all fit together.

3.5 Training courses

The increasingly complexity of business and social life, and the increasing number of new skills that are required to navigate them successfully, means that training is becoming even more important.

However very few of the online courses I have looked at have much understanding of hierarchical knowledge organisation and how it can be used to help learners learn more effectively. I imagine this is the case for many offline courses too.

Some of the problems include:

- a lack of knowledge maps showing the structure of the training so learners can work out at all times where they are in the training process
- a lack of summaries at different levels of detail so that learners find it difficult to review key points when they are going through the course or reviewing their knowledge after they have finished it
- an inability to differentiate between important information and subsidiary information so that all information is presented together on one level and learners have to go through, say, a 4 or 5 hour course and then extract for themselves what is important.

Increasing use of multi-level content could help to solve these problems.

PART 4: CREATING MULTI-LEVEL CONTENT

4.1 Moving between levels

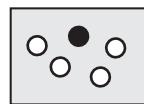
There are two main processes used for creating multi-level content:

- zooming in
- zooming out.

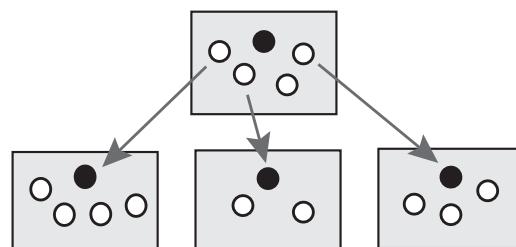
ZOOMING IN

1. The process of zooming in involves working out the various levels of sub-topics and detail that are needed for explaining a particular topic or for making a particular argument.

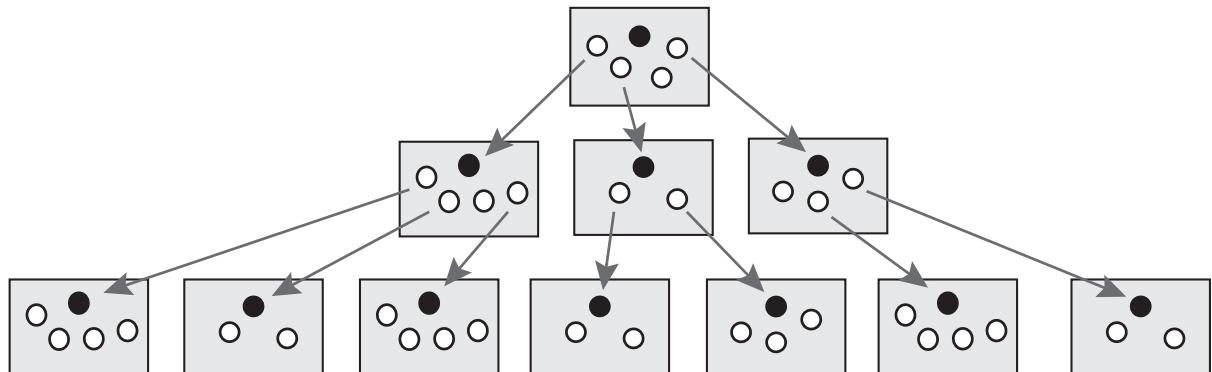
2. Putting the topic name or argument summary at the top, one then notes down the main knowledge elements that need to be examined.



3. Then on the next level down, one decides which elements on the top level need to be elaborated further. For each, one creates a new cluster with new category names or more detailed explanations.



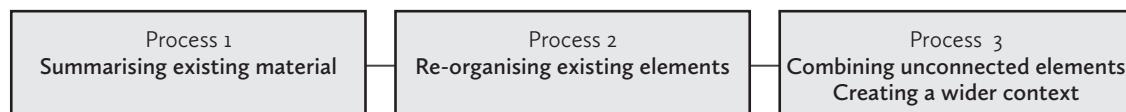
4. This process should be carried on for as many levels as is necessary. The number of levels will depend on one's objectives, and the amount and complexity of the knowledge that needs to be explained.



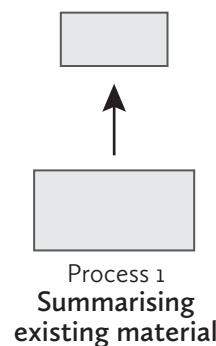
ZOOMING OUT

The aim of zooming out is to arrive at a summary big picture or a new big picture. It is a more complicated operation than zooming in as there are three different processes that can be used:

1. Summarising existing material
2. Re-organising existing elements
3. Combining unconnected elements or creating a wider context.

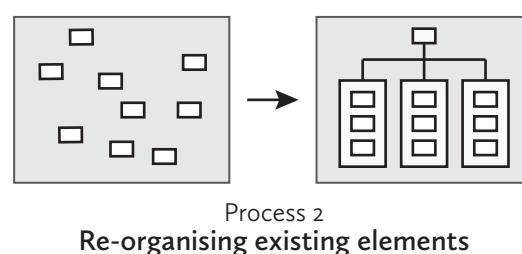


(i) **Process 1: Summarising existing material.** This process is about taking existing material and summarising the key elements of it (ie. going from more detail to less detail). Two examples of this are the *Deep Work* and the *All Out War* book summaries shown earlier on in the paper.



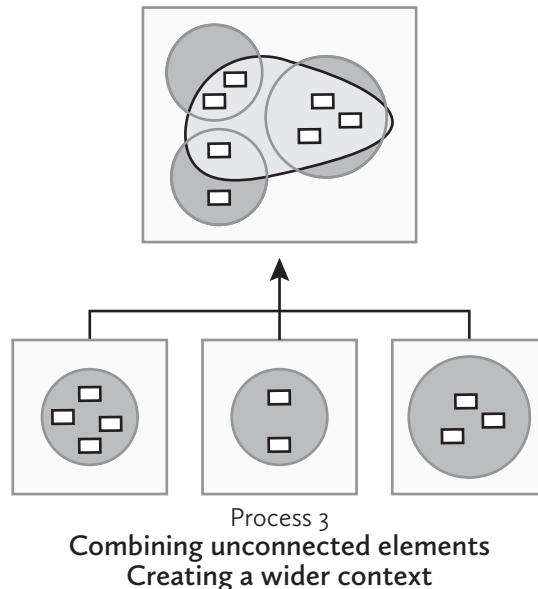
(ii) **Process 2: Re-organising existing elements.** This process starts with existing knowledge elements and looks to see how they can be re-organised to produce additional or new meaning – for example, through categorising, ranking, systematising or simplifying.

Buster Benson's categorisation of cognitive biases is an example of this second procedure. He started off with 175 cognitive biases organised into vague categories with some duplicates and decided “to come up with a simpler, clearer organizing structure to hang these biases off of”²².



²² From <https://betterhumans.coach.me/cognitive-bias-cheat-sheet-55a472476b18>.

(iii) **Process 3: Combining unconnected elements or creating a wider context.** This process is about creating new meaning by combining unconnected knowledge elements or by putting already connected knowledge elements into a new context. Mr Pink's map of the literary periods in English literature is an example of the latter. By placing writers in the context of the wider social and economic environment, he provides students with a more sophisticated understanding of their work.



The Linguisticator language maps can be viewed as a combination of ii) and iii).

The key processes involved in zooming out can include one or more of the following:

- **generalising:** going from the specific to the general
- **summarising:** creating a summary of detailed knowledge
- **categorising:** creating categories for unordered knowledge elements or re-arranging knowledge elements into new categories
- **contextualising:** putting knowledge elements into a wider context
- **systematising:** organising knowledge elements into a coherent system for analysis or action
- **comparing:** describing the similarities and differences of a number of knowledge elements
- **simplifying:** reducing unnecessary complexity
- **structuring:** combining knowledge elements into an ordered structure
- **connecting:** showing the relationships between different knowledge elements
- **ranking:** placing knowledge elements in order of importance
- **filtering:** separating the important information from the less important.

4.2 A dynamic process

At the beginning it's often obvious which process one needs to start with.

If there is a clear, circumscribed topic that just needs to be broken into more detail, then one will start with zooming in.

However, if one is beginning with only a hazy idea about how some knowledge elements are going to be organised or what context they are going to be put in, then zooming out will be the process to use.

However, soon after starting, it may well become a more dynamic process as one switches between structure (ie. naming the relevant knowledge elements or categories and showing how they are connected) and explanation, and one moves up and down the levels of both or either of them.

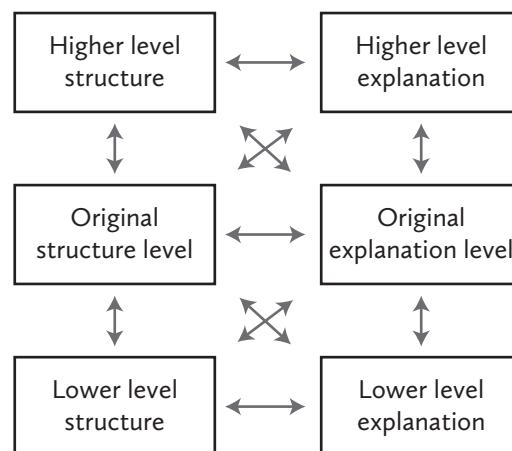
Some people like to jot down category names and draw relationships between them. In this way, they are beginning to establish structure and the different levels on which categories belong. They may then move on to adding explanation to the category names.

Others may begin with the detailed explanation and, as they decide to move a paragraph to a place where it fits better, start to amend the structure of their content in this way.

Initial structures and explanations are subject to ongoing change as you realise that:

- you've missed out an important topic
- the original structure you developed doesn't quite fit together so needs to be re-organised
- a topic that you thought you could address with a quick summary requires further elaboration
- you haven't explained the connections between one topic and another.

As gaps in structure or explanation become apparent, one ends up with multiple options.



When working on an explanation, one has a choice of:

- staying on that explanation level
- creating an explanation on a higher level
- creating an explanation on a lower level
- moving to work on the structure of the current level
- moving to work on a higher structure level
- moving to work on the lower structure level.

Mirror options are available for when working on structure.

This process may seem horribly and unnecessarily complicated but it's what most people are doing unconsciously as they struggle with the challenges of structure and explanation.

However, having a clear understanding of the difference between structure and explanation and of the concept of multiple levels allows for more deliberate strategies.

If you are feeling stuck or struggling to express what you want to communicate, it can help to consider:

- changing from working on structure to explanation or vice versa
- moving up or down levels of structure or explanation.

4.3 Making implicit knowledge structures explicit

There is another way of organising knowledge, which is to start with some existing text or a spoken explanation and make the implicit knowledge structures within them explicit.

In a simplified form, the process involves:

- identifying the overarching knowledge structure and the subsidiary structures used
- working out how all the knowledge structures connect to each other
- deciding on the number of knowledge levels that work best for the explanation
- creating new knowledge maps where needed
- identifying the big picture summaries needed for the different levels and then either extracting existing text or creating new text.

4.4 Making hierarchical knowledge organisation more useful

Frederick Reif suggests four practical ways to make the process of hierarchical knowledge organisation more useful²³:

1. He writes about the “useful size of a cluster” and suggests that clusters shouldn’t be so big that the amount of knowledge in them becomes overwhelming. But they also shouldn’t be so small that it becomes impossible to understand the relationships between an excessive number of clusters.
2. “Internal organisation of a cluster”. As already mentioned, while the overall organisation of knowledge within a topic or category should be hierarchical, the knowledge organisation within clusters doesn’t have to be hierarchical: “It is helpful if the knowledge *within* each cluster is also organized in an easily manageable way. (For example, it might be organized hierarchically in some clusters, or organized in different useful ways in some other clusters.)”
3. “Overlapping clusters”. Where necessary and, in particular, where context is helpful, the same information can appear in nearby clusters. Reif gives the analogy of state maps which don’t end at their exact borders but also include parts of neighbouring states. This allows drivers to move between maps more easily.
4. “Cross-references”. It can be helpful to cross-reference related knowledge that isn’t in a hierarchical relationship.

²³ All the quotes in this section come from *Applying Cognitive Science to Education: Thinking and Learning in Scientific and Other Complex Domains*, Frederick Reif, MIT Press, 2010, pp.146-147.

4.5 Different aspects of hierarchical knowledge organisation

As discussed in Part 2, there are a number of key aspects or sets of distinctions involved in hierarchical knowledge organisation. They include moving:

- between the big picture and the detail
- between important knowledge and subsidiary knowledge
- between the whole and the parts
- between general knowledge and specific knowledge
- between a wider context and a narrower focus.

(Definitions of these different terms can be found in Appendix 2.)

It can be helpful to check systematically whether all the different aspects have been covered and, if not, whether it would be useful to do so.

Here are some questions that can be asked.

BIG PICTURE/DETAIL

Have I provided a general overview of the topic that adequately sums up all the detail?

Have I provided enough detail to back up the argument I am trying to make, or the ideas or concepts I am trying to explain?

Important/subsidiary knowledge

Have I adequately differentiated the knowledge that is of critical significance from the knowledge that is of secondary value?

WHOLE/PARTS

Have I adequately described the different ways in which the individual parts combine to make up the whole?

GENERAL/SPECIFIC KNOWLEDGE

Have I adequately identified the rules and principles that are true in general and what the exceptions or anomalies are?

WIDER CONTEXT/NARROWER FOCUS

Has the wider context of the topic been sufficiently covered or has there been too narrow a focus on individual topics?

4.6 Choosing between single and multiple knowledge levels

Choosing between having a single knowledge level or multiple ones will depend on the complexity and depth of a topic or argument - as well as how much detail needs to be communicated.

For example, the large quantity of information described in the Cognitive Bias Codex means that having an additional higher level summary map makes the knowledge more usable for those who don't need that level of detail.

On the other hand, the map of Hitler's rise encompasses quite a limited amount of information that works well on a single level of detail. However, if more detail was needed or a wider context was being looked at, such as Hitler's life as a whole, then multiple levels of detail would become appropriate.

4.7 Organising knowledge: difficult or easy?

Frederick Reif makes the important point that “creating an effective organization of some knowledge is a much more complex task than that of using such an organization”²⁴ and gives the example of a geographical map. It’s clear that, while everyone can use a map, it’s beyond the capabilities of the vast majority of us to actually do the surveying, drawing and design involved in creating a map ourselves.

Richard Watson’s experience of working on his Mega Trends and Technologies map is instructive. As already described, it took him around two years to complete the map and involved drawing about 22 versions by hand before he came up with a final version he was satisfied with.

Aaron Ralby’s experience mirrors this. Discussing the challenges of producing a language map of Modern Standard Arabic, he writes:

“Nothing.... beats the tedious process of mining grammar after grammar to make sure that I’ve scooped up every last detail about how the system works. I’ll think I have it, then read something new that will crack open a whole new series of questions that need answering. Following the trail, the rabbit hole is sometimes very deep indeed; but there is always a bottom.”

Being able to create a complex and comprehensive knowledge map requires:

- a reservoir of knowledge
- patience and creativity in identifying themes and patterns that will usefully connect different knowledge elements
- a commitment to structuring knowledge in ways that will be interesting and informative to learners.

However, that’s not the whole story. It’s important that people aren’t put off learning to organise information themselves by thinking they must meet exacting professional standards.

While most of us don’t have the skills to create a geographical map that is professionally surveyed and designed, everyone can draw some simple directions to show where they live. Similarly, a knowledge map doesn’t need to have a sophisticated design or to be intended for public consumption.

For example, Mr Pink drew his map of the literary periods in English literature on the back of an envelope and it’s no less useful because of that.

Creating a knowledge map can be as simple as writing the names of a few categories or facts on a piece of paper and then working out what lines to draw to connect them most effectively.

The benefits come from the thought and understanding required to connect different knowledge elements together and how the map actually looks is of little importance.

²⁴ *Applying Cognitive Science to Education: Thinking and Learning in Scientific and Other Complex Domains*, Frederick Reif, MIT Press, 2010, p.149

CONCLUSION

Hopefully this paper has proved to be a useful introduction to knowledge maps, hierarchical knowledge organisation and multi-level content, and the potential they bring to making knowledge easier to understand, remember and communicate.

There are many areas that I intend to write about in more detail in the future, including:

- the power of diagrams to help explain complex ideas
- a deeper dive into the different types of knowledge structures
- how to make knowledge easier to put into action.

I hope many people will join me in helping to develop the concept of multi-level content further.

ACKNOWLEDGEMENTS

I have been heavily influenced by **Frederick Reif** and his work on the concept of hierarchical knowledge organisation, which is outlined in Chapter 9 of his book [Applying Cognitive Science to Education: Thinking and Learning in Scientific and Other Complex Domains](#) (MIT Press, 2010).

The holographic/linear concept outlined in **Ian Harris** and **Oliver Caviglioli**'s book [Think It – Map It!](#) (Network Educational Press, 2003 – pp.28-33) has also been very helpful in developing these ideas – as has been **Oliver Caviglioli**'s work in general on educational ideas and how they can be explained more effectively through visuals. Oliver was also the person who pointed me to Frederick Reif's book via a tweet.

I have found **Richard Koch**'s thinking on the 80/20 Principle very valuable ([The 80/20 Principle: The Secret of Achieving More with Less](#), Nicholas Brealey Publishing, 2003). His suggestion that 80% of the value of a book can come from 20% (or less) of the text was one of the key ideas that helped to start me off on this journey exploring the structure of knowledge.

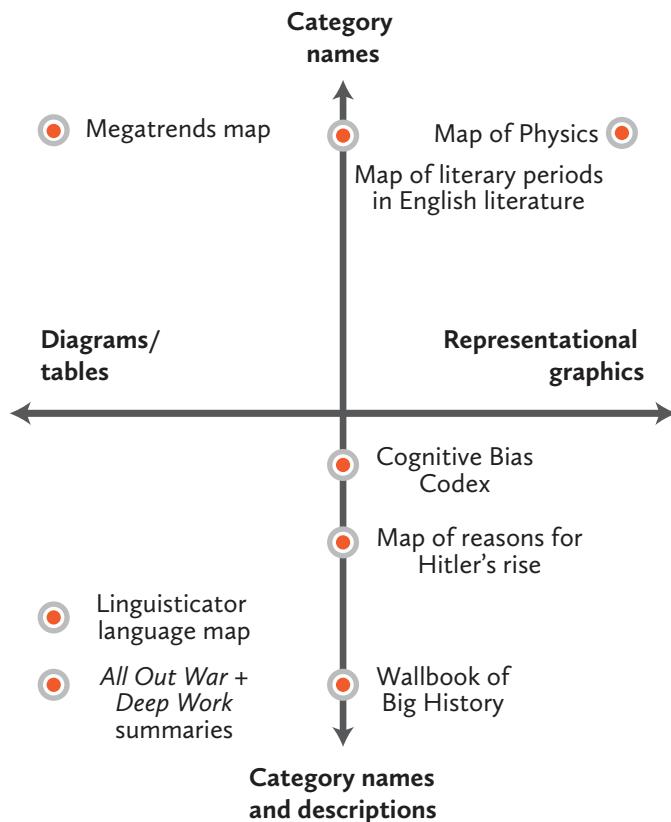
Kristopher Boulton's [blog post on knowledge organisation](#) provoked many useful thoughts about knowledge organisers and about knowledge organisation more generally.

Lynne Kelly's [blog post about Asian narrative scrolls](#) and how they tell stories on an extended canvas helped to crystallise my thinking about big knowledge maps. Lynne is an Australian writer who is doing some exciting and imaginative work on the importance of memory systems in pre-literate societies and how memory systems can be used to improve memory.

My thinking about structuring and organising knowledge has been influenced by the ideas of architect and systems thinker **Christopher Alexander** (a good introduction to his ideas is [Pattern Theory](#) by **Helmut Leitner**) and by two books written by the architectural theorist **Nikos Salingaros** - [A Theory of Architecture](#) and [Twelve Lectures on Architecture: Algorithmic Sustainable Design](#). Interestingly, both have backgrounds in mathematics. Alexander's first degree was in mathematics while Salingaros is a professor of mathematics amongst his many other activities.

Finally, thank you to everyone who has listened to my explanation of these ideas over the last year or so. Those who understood what I was talking about provided much needed encouragement. Those who responded with blank looks spurred me on to develop more comprehensible explanations.

APPENDIX 1 – AN EXPLANATION OF THE CATEGORISATION OF THE KNOWLEDGE MAPS



Megatrends map - this is in the top right corner as the map is purely a diagram and uses category names without descriptions (although the map also has a general explanation at the side of it).

Big History Timeline Wallbook: this is at the bottom on the vertical midline. It has many descriptions in addition to category names. With regard to graphics, the map uses both a timeline and illustrations within the timeline.

Cognitive Bias Codex: the categorisation of this map is not clearcut. I have put it below the horizontal midline and on the vertical midline. I don't think the brain illustration is purely decorative as it does add some meaning. In addition, the categories of cognitive bias areas have elements of description within them.

Linguisticator French language map: this map is placed towards the bottom of the bottom left-hand quadrant. There is a huge amount of description within each of the tables. With regard to graphics, the few illustrations are mainly decorative and don't provide much meaning so I've kept the entry close to the left-hand edge.

Map of Physics: this map uses illustrations as well as category names without descriptions so is placed in the top right-hand corner.

Hitler's rise: this map is placed towards the bottom on the vertical midline. It adds representational graphics to the timeline and the category names also have descriptions.

Literary periods in English literature: this map is on the vertical midline as it uses both a timeline and graphics. I've also put it at the top as it has category names without any descriptions.

Summary of *All Out War*: this map is in the bottom left-hand corner as it consists of diagrams without any representational graphics. In addition, the category names also have descriptions.

Summary of *Deep Work*: I've put this map in the bottom left-hand corner as it just uses tables and a diagram without any representational graphics. There are also descriptions in addition to the category names.

APPENDIX 2 – DEFINITIONS OF THE DIFFERENT TERMS ASSOCIATED WITH KNOWLEDGE ELABORATION

Big picture

“A broad overview of a situation, issue, or problem; a wide perspective or appraisal, especially regarded as an effective way to identify essential features or evaluate overall aims and strategy” ([Oxford Dictionaries](#))

“A broad, overall view or perspective of an issue or problem.” ([Dictionary.com](#))

Detail

“Extended treatment of or attention to particular items” ([Merriam Webster](#))

“Attention to or treatment of a subject in individual or minute parts” ([Dictionary.com](#))

Important

“Of great significance or value” ([Oxford Dictionaries](#))

“Marked by or indicative of significant worth or consequence” ([Merriam Webster](#))

Subsidiary

“Less important than but related or supplementary to something” ([Oxford Dictionaries](#))

“Subordinate or secondary” ([Dictionary.com](#))

Whole

“Complete or not divided” ([Cambridge Dictionary](#))

“Containing all the elements properly belonging; complete:” ([Dictionary.com](#))

Part

“A portion or division of a whole that is separate or distinct; piece, fragment, fraction, or section; constituent” ([Dictionary.com](#))

“An amount or section which, when combined with others, makes up the whole of something” ([Oxford Dictionaries](#))

General

“Concerned or dealing with universal rather than particular aspects” ([Merriam Webster](#))

“(Of a rule, principle, etc.) true for all or most cases” ([Oxford Dictionaries](#))

“Of, relating to, or true of such persons or things in the main, with possible exceptions; common to most” ([Dictionary.com](#))

Specific

“Specified, precise or particular” ([Merriam Webster](#))

“A description that is precise and exact” ([Collins English Dictionary](#))

Context

“The circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood” ([Oxford Dictionaries](#))

“The interrelated conditions in which something exists or occurs” ([Merriam Webster](#))

Narrow Focus

“A center of interest or activity...limited in area or scope” (Free Dictionary – [focus](#) and [narrow](#))