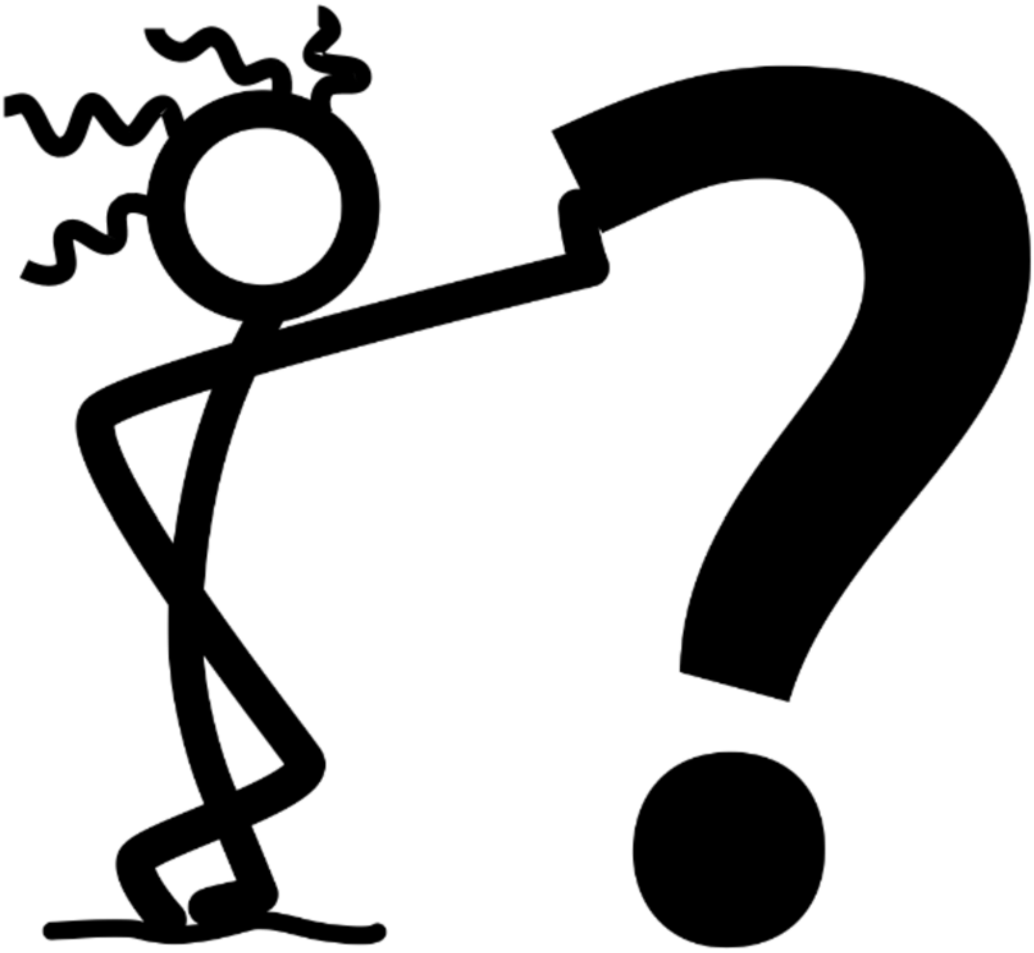
The Round – What should we know about k…

What should we *know* about *knowledge*?

Summer 2021



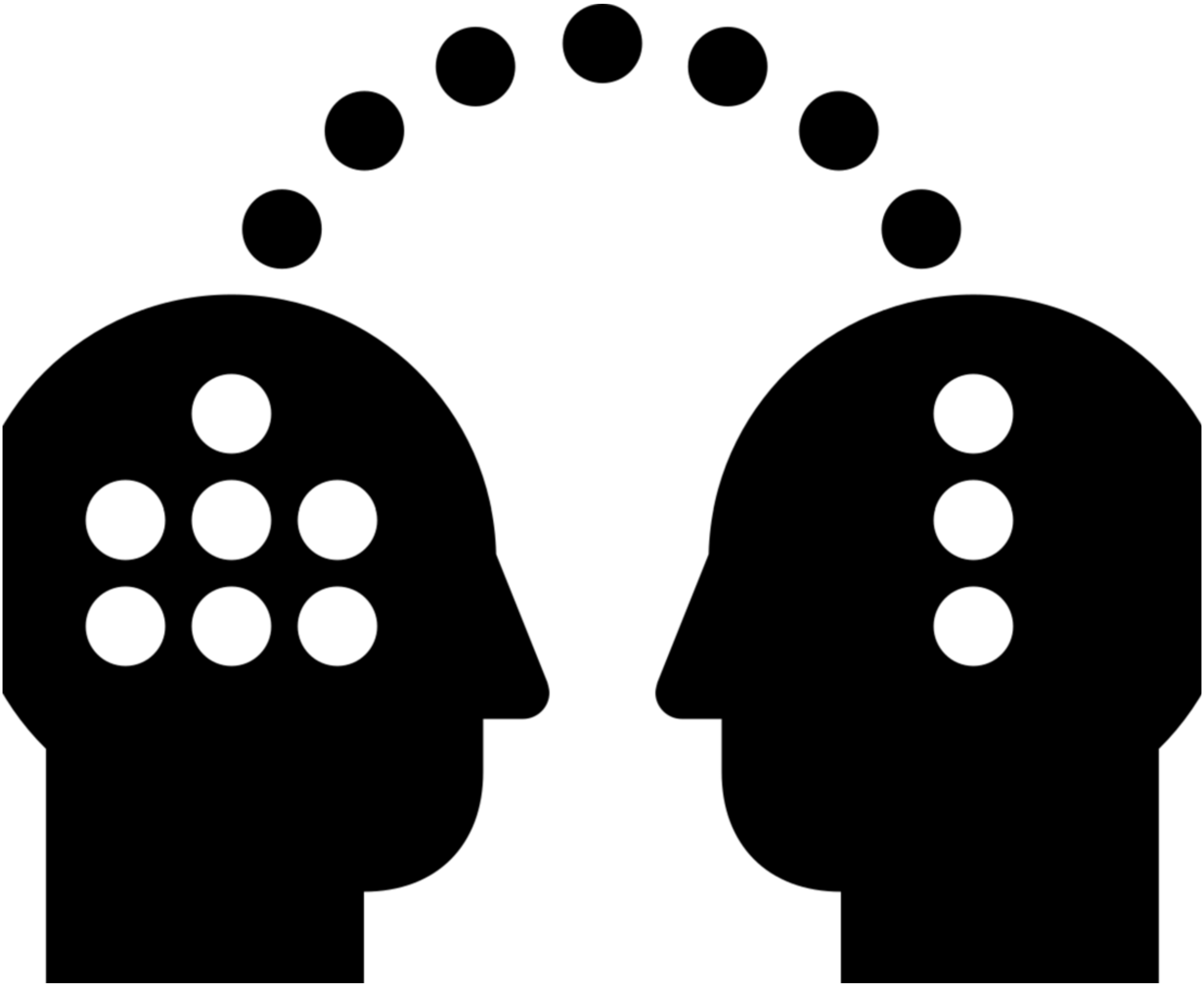
Things to know about knowing

Welcome to this special edition of The Round – the Wildern community's very own professional development bulletin, aiming to keep you up to date with some big ideas in research and education. In this edition, I've chosen to share with you ideas and research on the topic of knowledge. Our understanding of the importance of the acquisition and retention of knowledge in learning has moved on a lot over the past decade, but there are still some really important concepts and theories that can help us even further when it comes to ensuring pupils have the requisite knowledge for success in our subjects.

There are three articles in this edition:

1. The Curse of Knowledge – a short article about this cognitive bias that sometimes gets in our way as experts in our subjects.
2. How to remember anything, forever – a video of Daisy Christodoulou's presentation for last year's *researchED at Home*, in which she talks through what evidence from cognitive science tells us about the best ways to embed knowledge so that it sticks.
3. Core and hinterland: what's what and why it matters – an article by Adam Boxer about these two concepts of knowledge, both of which I'm sure we all use in the classroom, but maybe hadn't thought about the distinction before.

The Curse of Knowledge



Also known as 'expert blindness' or 'expert induced blindness', this cognitive bias means that our own expertise can sometimes stand in the way of teaching effectively.

As teachers, we are experts in our domains. Our pupils, for the most part, are novices. Sometimes our expertise means that we may not account for this difference. This is a cognitive bias called *the curse of knowledge*. As I've said before, cognitive biases aren't something to be ashamed of – they are what make us human. But we should try to be aware of them and try and account for them where we can.

Before we delve into the curse of knowledge, let's do an experiment.

1. Firstly, find a partner.

2. Next, think of a tune in your head – don't say it out loud!

3. Tell your partner that you are going to tap out a tune for them and they are going to listen to it and guess what it is. Ask your partner not to give away whether they know it or not as they listen.

4. When you have decided on your tune, tap it out on the table for your partner, ensuring that you don't hum along or sing it. Just tap it out.

5. Now, before you ask your partner to guess what they think that tune is, try to predict whether you think they will get it right.

6. Ask them what the tune is.

Did they get it? Did you correctly predict whether they would get it or not? Did you think they should have got it from your expert tapping? I mean, it was pretty obvious, wasn't it?

This test was actually part of study presented in the dissertation of Dr Elizabeth Newton, a then doctoral student at Stanford University. In her study, Dr Newton assigned participants to be either tappers or listeners. Each tapper finger-tapped three well-known tunes on a desk, and was then asked to guess the probability that the listener would be able to identify the song. On average, tappers estimated that listeners would be able to identify around half of the tunes that they tapped out. In reality, listeners were only able to identify just over 2% of the tunes. Even the most pessimistic tapper estimated that the listeners would get around 10% correct (some went as high as 95%!)

This experiment tells us something about the relationship between what we know and our assumptions of other people's knowledge: when something is absolutely clear in our head, we find it hard to imagine what it is like to not have that knowledge. This failure to account for the fact that others don't know the same things that we know is called *the curse of knowledge* or *expert blindness*. This bias is most common in the field of teaching as it is an area that deals with experts and novices. Those that are more knowledgable in a domain often fail to acknowledge this difference and just assume that what we are explaining is clear. Because to us it is.

As such, the curse of knowledge can make it difficult for experts to teach novices. For the most p as teachers, we do try and account for it, but it is useful to be aware of it so that we can make further concessions. One of the times we might be more aware of it as teachers is when we observe lessons outside of our subjects. Because we aren't experts, we are more likely to observe when an explanation assumes knowledge that we don't have. But it is likely that we have fallen into this trap too.

I witness this cognitive bias in play when pupils are asked to produce creative writing in English. When writing narratives at GCSE, pupils are often encouraged to either write about a real experience or an imagined one. When they write about an imagined one, pupils often describe it better than when they write about a real experience. This is because when describing the real experience pupils don't account for the reader's lack of knowledge of what is happening in the narrative. This is knowledge the pupils take for granted. They miss parts out that are vital to understanding what is going on in the story, but the curse of knowledge means that they have just assumed the reader has the same understanding as them of the situation. As the imagined experience is being made up on the spot, pupils tend to describe it better as it isn't based on expert knowledge from the writer, so no assumptions are made.

So how do we account for the curse of knowledge? Well, one thing we all do anyway is to get feedback from pupils to confirm they understand what we are saying. Another way to prevent some of the issues from this bias is to ensure that we explain all technical terms and concepts as we are using them – even if they seem obvious to us.

We experience the curse of knowledge because it is really hard to imagine what it is like to not have the knowledge that we have. Simply being aware of this fact is the best start in ensuring we account for it.

How to remember anything, forever

Daisy Christodoulou

Director of Education at *No More Marking*, and author of '7 Myths about Education', 'Making Good Progress' and 'Teachers vs. Tech'

This is a video of talk given by the brilliant Daisy Christodoulou as part of 2020's *researchED at Home* sessions. In this presentation Daisy talks through what evidence from cognitive science tells us about the best ways to embed knowledge so that it sticks.

Core and hinterland: what's what and why it matters

Adam Boxer

Head of Science at The Totteridge Academy (North London), Editor of CogSciSci

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*Adam has kindly allowed us to reproduce his article on the ideas of **core** and **hinterland** knowledge here. I think these concepts are fascinating and so important to thinking about what we do daily in the classroom with regards to knowledge transfer, as well as in how we plan our curriculum within our subjects. Adam uses his subject of Science to give examples here, but these concepts are as important and applicable across the wider curriculum. You can read more of Adam's writing at his blog, A Chemical Orthodoxy.*

In 1918, the Nobel Prize for Chemistry was awarded to a war criminal.

In the early years of the 20th century, German scientist Fritz Haber developed a process to artificially synthesise ammonia, a vital component of agricultural fertilisers. A reaction that changed the world, his process drove a ballooning in industrial agriculture and, with the fullness of time, allowed for a population explosion and the pulling of billions of people out of poverty.

But Haber's oeuvre extended from the globally beneficial to the sinister. A fervent nationalist, in World War I he turned his brilliance to the German war effort and pioneered the use of chemical weaponry on the battlefield, personally supervising the first administration of deadly chlorine gas in the trenches of Flanders.

Despite these contributions to the Fatherland, Haber was forced to leave Germany because he had Jewish ancestry: an ancestry he despised. In a grimly ironic turn of historical events, the laboratory which he had headed went on to be instrumental in the production of the chemical Zyklon B, a chemical used by Hitler's SS to murder hundreds of thousands of Haber's own people in the gas chambers at Auschwitz.

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The Haber Process has been on the GCSE Chemistry curriculum for many years and every year when I teach the process, I tell Haber's story. As a Jew and as a teacher of science, it's important to me and it serves as the most extreme of cautionary tales about the role of science in modern society. But I don't expect my students to remember its details. I don't have a knowledge organiser chronicling its events, or expanding the discussion to Haber's tragic family life and the suicides of his wife and son. There are no assessment questions in our end of unit test asking students to evaluate the significance of science's contribution to World War I. I set no drill questions on the viability of gas as a weapon of war.

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When discussing curriculum, Christine Counsell presents a paradox at the heart of curricular choice: on the one hand, we all know that there is content which we wish students to remember, and by contrast content we cover in class which we don't deem necessary for them to remember. This would ordinarily lead us to de-emphasise the latter in favour of the former. The other hand of our paradox though is that without that material, without the "stuff we don't need our students to remember," our curriculum becomes denuded of wider meaning and majesty: it ceases to be one thread of the epic story of humanity and becomes a sterile and sanitised exam-ready product.

To aid us in thinking about this paradox, Counsell posits the use of two terms: core and hinterland. Such terms are not carved-in-stone categories, delivered by God to Moses at Sinai. They are intellectual devices which should serve as a prompt for us to reflect on, and clarify, our curricular decision-making.

I think of core as the stuff I want my students to remember and to stick in their long term memories: all the details and propositions that make up the cognitive architecture of a creative and innovative scientist. Hinterland is how I frame that knowledge: the stories I tell and the examples I use. It's the ground from which the core springs. So in my example, the core includes the equations for the Haber process, the effects of changing conditions on the equilibrium, the idea of a compromise condition and so on and so forth. The tale is how I frame it. Haber's process is core, Haber's story is hinterland.

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This is an incredibly powerful distinction to be made when thinking about science, and indeed all, curriculum. When we are teaching, what is it specifically that we want students to remember, and what is it specifically that we use to make it memorable? I can imagine this question cropping up across the sciences and across the key stages, and I would like to try and explain why ignorance of it may be responsible for some curriculum faux pas.

We know that an exam specification is not a curriculum, but let's take a fairly common section from the GCSE syllabus: the history of the atom. The spec goes into quite a bit of detail about the different models of the atom proposed by various scientists, and the experiments that moved them from one model to the next. In the AQA syllabus the entire section is prefaced by:

> *New experimental evidence may lead to a scientific model being changed or replaced.*

Ah! To me, that's core. An incredibly important point, perhaps the most fundamental concept in the disciplinary substance of science. Evidence is king, and we are but servants before it. Beautiful.

But I would argue that using the history of the atom to illustrate it is hinterland. Is it really important that GCSE students know about how alpha scattering proves that the plum pudding model is wrong? Or that they know the names of Niels Bohr and James Chadwick specifically? Why these chemists? Why are these specifically the only named chemists in the entire specification? Are these the best examples to discuss how experimental evidence leads to scientific models being changed or replaced? What about phlogiston and the conservation of mass? What about Grecian Classical Elements? What about the now-excised-from-the-curriculum theories of continental drift or land bridges? What is the core here, and what is the hinterland?

Further, there is perhaps even an incoherence at play here as we compare the following statements:

> *The results from the alpha particle scattering experiment led to the conclusion that the mass of an atom was concentrated at the centre (nucleus) and that the nucleus was charged. This nuclear model replaced the plum pudding model.*

> *Niels Bohr adapted the nuclear model by suggesting that electrons orbit the nucleus at specific distances. The theoretical calculations of Bohr agreed with experimental observations.*

It looks to me like students need to know the details of the alpha particle scattering in a way that they don't for Bohr's experiments. But why? Why do they only need to know that his that they don't for Bohr's experiments. But why? Why do they only need to know that his calculations agreed with observations, a fact that is true, but surely not particularly exciting, powerful or far-reaching? The same is true of later developments, students are just expected to know that they occurred, but not to know why or how those developments came about:

> *The experimental work of James Chadwick provided the evidence to show the existence of neutrons within the nucleus. This was about 20 years after the nucleus became an accepted scientific idea.*

If we were writing from scratch, and we had core and hinterland in mind, would we make these curricular decisions? I'm not convinced we would.

Let's look at another contender for hinterland: "real world" applications of scientific principles. Extraction of aluminium is probably a good one, where we expect students to learn that in the industrial extraction of aluminium, graphite anodes need to be replaced by factory owners as they react with the oxygen by-product of the electrolysis of aluminium oxide. Honestly, who cares? Does it really matter? Do GCSE students really need to know it? Is it really core? I can certainly imagine that there is a chemistry teacher out there who used to work in that industry, and probably tells their class stories of how they needed to replace the graphite electrodes. I have no doubt that I would enjoy being in that teacher's class and that the hinterland they prepared was fertile for the planting of more fundamental and further reaching ideas. But I am not that teacher, and that hinterland is not the land that I would choose at the best of times: and now I am being tasked with calling it core.

To me, this represents a deficit in our curricular thinking – a failure to appreciate a vital distinction. Briefly, I would like to discuss two further ramifications of this distinction: scientific "application" and how pedagogy changes depending on whether that-to-be-taught is core or hinterland.

Application

It would be quite easy to think of "application" questions as hinterland. For example, if a student is asked why the mass of magnesium increases when it is reacted with oxygen, it would be straightforward to think that the core knowledge here is "the law of conservation of mass," with my hinterland being "isn't this a cool example? The metal's mass actually goes up when I burn it into this crumbly white powder!"

I'm sort of in two minds about this. On the one hand, sure. It's just one example of a principle that works across the whole of chemistry. On the other hand, can you learn that principle without examples? Is the example a bit more than just an embellishment but a concrete scaffold, a fixed point in space that navigates us towards the broader principle? If that scaffold were taken away, would the core concept still be retained? I don't know, and we decided in our KS3 curriculum that it would be a core idea, and we expect students to memorise how and why the mass of magnesium changes. Even more so, we use it as a "canonical example" in our How Science Works unit: because students know the principle well, it allows us to use it as hinterland in our discussion of theories, evidence and scientific conclusions. Yesterday's core is today's hinterland.

hinterland.

I'm not sure there's a ready answer to this, but it underlines the need for us as a disciplinary community to discuss and establish the parameters and justifications for our curricular decisions.

Pedagogy

Looking back, I find that my classroom craft changes depending on if I am teaching core or hinterland. Core is always straightforward: I break a topic up into small pieces, I use a lot of boardwork, ask a lot of questions and students do a lot of practice. I don't move around the class too much, I try not to be too dramatic and try not to vary my intonation and speech patterns. I use technical but unembellished and prosaic language.

Quite the opposite tends to be the case when I walk in the hinterland. I move around the class more, I become physically animated and visibly excited. I vary my intonation and use poetic and emotive language. I can often talk for a long time without pause, without asking questions and without students taking notes or doing drill questions. I draw on my personal feelings and experiences in a way that I rarely do in my other interactions with students, I give just a little bit more of myself. When discussing Haber I talk about the pain I felt as a chemist when I stood in the gas chambers at Majdanek and saw the vivid blue stains on the walls, knowing it to be "prussian blue," a characteristic residue of cyanide containing compounds. Standing in the hinterland is just…different. I know it's different, the students know it's different, and it serves to thoroughly underscore – to weave into the very fabric of our education system – that curriculum must precede pedagogy.

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Core and hinterland are not fixed, firm categories. As above, what may be hinterland one day may be core another day. Haber's story might be hinterland in science, but could be core in History, or in the History of Science. They aren't bounded terms with indisputable meanings and parameters. They are tools for reflection and deeper curricular thinking. If we turn them into non-negotiables in curricular planning, and demand a central document for every faculty detailing which concept is which we will have missed the point.

I've tried above to show how this tool has influenced my thinking, how they have pushed me to consider my content and my teaching in a different light. I think that's the spirit in which they should be used.

Much of the above is exploratory and, as I have said before, I am just starting out in my journey of thinking deeply about curriculum. But I doubt I'm alone. We need, as a subject community, to discuss this. We need, as a subject community, to utilise the tension and the paradox to grow intellectually, to sharpen our discourse and to reflect more meaningfully on what is indubitably the most important part of our teaching: the curriculum.

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T… above is my contribution to the Curriculum in Science Symposium. Our biggest symposium yet. I encourage you (scientist or no) to read the other contributions, links to which can be *yet, I encourage you (scientist or no) to read the other contributions, links to which can be found here.*

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I am incredibly grateful to Christine Counsell for providing me with feedback and guidance in writing the above. She is truly a force for good in our education system, and I am glad that the winds are finally beginning to shift in the direction she has advocated for many years.

I hope you've found these articles and videos useful. If there is a topic or idea you'd like to see explored in a future edition, please drop me a line.

As always, you can email me with any questions or recommendations: j.theobald@wildern.org

Or you can drop by and find me in Room 108 if you want to discuss anything relating to these topics or other areas of research.

James