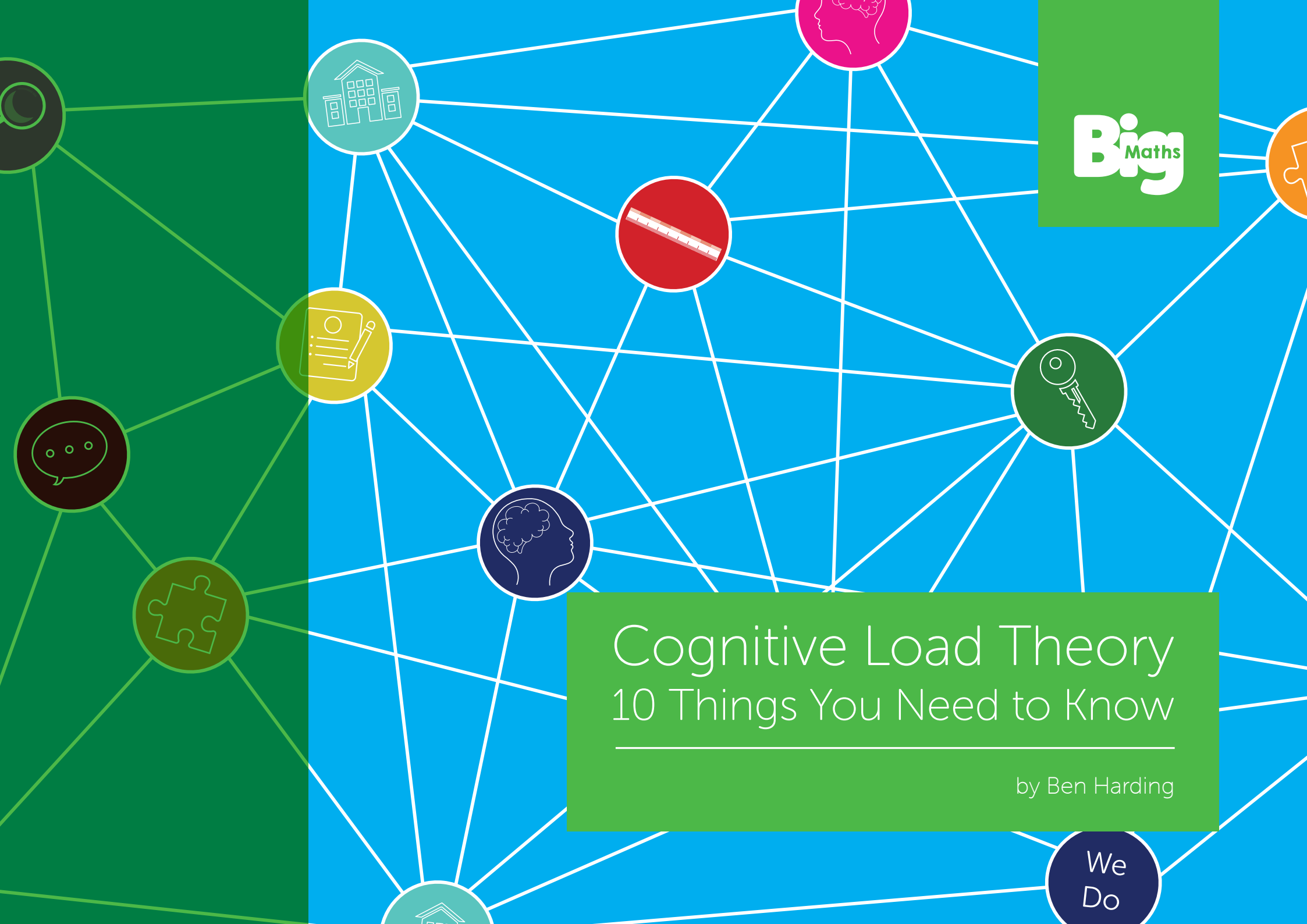

Big Maths
Cognitive Load Theory
10 Things You Need to Know
by Ben Harding
We Do

Cognitive Load Theory has several interweaving dimensions. This booklet provides an introductory guide to CLT. It uses the acquisition of numeracy skills as a straight forward context for illustrating wider CLT principles. There is, of course, more depth to be found within each of these 10 aspects. For more information visit my blog ('Ben Harding's Blog') which is found at BigMaths.com.

Research

It is important to note from the outset that CLT has arisen from many years of robust educational research. John Sweller has been described as the 'Godfather of CLT', and it was he and his colleagues that started carrying out the research and developing the ideas around CLT. Although this started in the 1980s, to this day CLT continues to find and use evidence about how the brain learns to inform principles for teaching.

The intent of this booklet is merely to support you in beginning to apply the basic principles of CLT to your teaching, whatever the subject may be. Indeed you may well find that many of the implications from CLT research are already part of your practice!

"...the acquisition of numeracy skills as a straight forward context for illustrating wider CLT principles"

> "...the intent of this booklet is merely to support you in beginning to apply the basic principles of CLT to your teaching, whatever the subject may be"

The 10 Things You Need to Know!

A Summary for Teachers and School Leaders:

1. The working memory of the brain is very limited.
2. Use explicit instruction for new content.
3. New knowledge needs to be transferred to the long term memory, ready for retrieval and transfer.
4. Learning happens through schema extension and connection.
5. Break the curriculum down into very small chronological parts.
6. Know the learner's background knowledge.
7. Focus the attention of learners on the new content...only!
8. Teaching becomes redefined as 'focussing, guiding and responding'
9. Identify the key schemas operating across the bigger learning journey.
10. Systemise CLT across the school to maintain CLT principles and reduce workload.

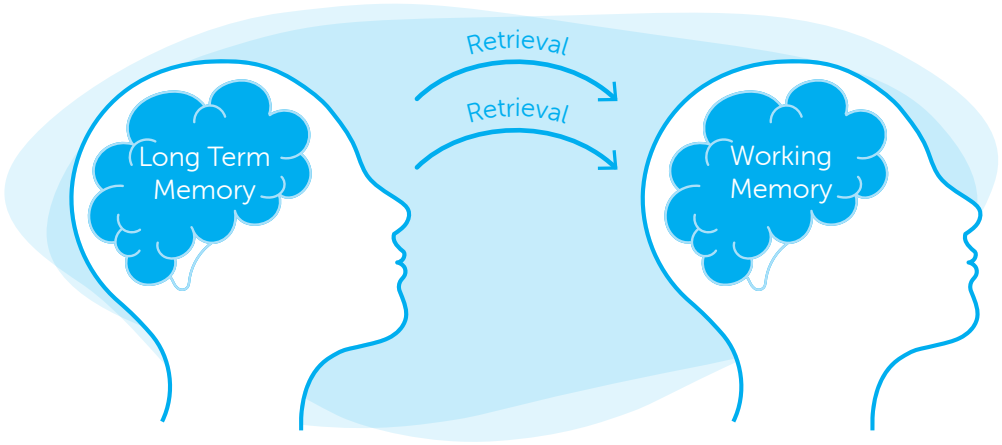
1

The Working Memory of the Brain is Very Limited

The human brain's Working Memory (WM) is the part that processes information in the present moment. It is very limited. It can only process a small amount of new information at one time. However, it can work much better if it is able to retrieve relevant knowledge (facts/skills/concepts) stored in the brain's Long Term Memory (LTM).

Example

Only if the learner can retrieve double 3 fluently, and can also retrieve double 20 fluently, will the learner be able to double 23 for the first time without overloading the working memory.



Cognitive Load Theory is about not overloading the working memory, and about not underloading the working memory. CLT is about getting the load right.

If the brain is working to process information then it is not yet a part of a fluent 'schema' in the LTM. This adds high demand on the working memory, which can become overloaded and fail to process the new information. In order to avoid this cognitive overload we have to build on top of existing fluency. Fluency is always built on top of fluency.

2

Use Explicit Instruction for New Content

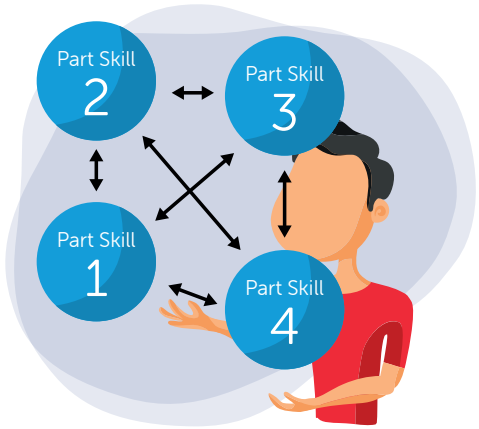
I Do

We Do

You Do

When teaching new knowledge, don't leave learners to figure it out for themselves. This is inefficient and overloads the working memory. Problem solving and challenging questioning come later. Instead, teach new knowledge directly and explicitly through worked examples.

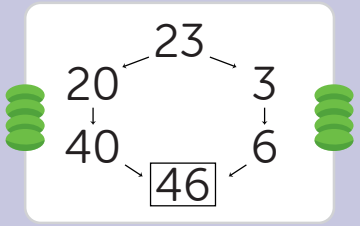
Use 'Remember To...' statements to structure and scaffold the new process. Each RT statement is an 'already fluent part-skill'. This way the working memory isn't overloaded.



Example: Doubling 2-digit number

Remember To:

- Partition the numbers
- Double the ones
- Double the tens
- Recombine the numbers



The Classic CLT Explicit Teaching Input Has Three Stages:

i. (I do) Show children the whole process, modelling with 'out loud thinking'.

ii. (We do) Then guide learners through the process, bolting together the 'Remember To' statements one at a time, checking 'understanding' and 'doing' through questioning as you go.

iii. (You do) Once children can move through the whole skill independently then leave them to practise and make the new process smooth.

Before Moving On:

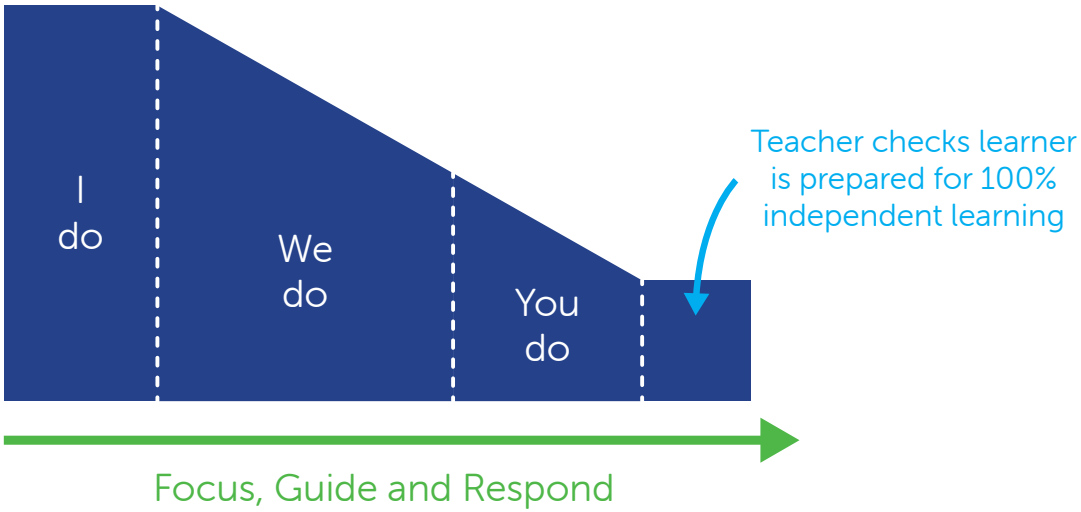
Looking at a representation of this teaching sequence, we can see how the teacher constantly focusses, guides and responds to learners:

I Do: The teacher having complete responsibility for the process as they model it; then,

We Do: Typically with a longer period of time, working collaboratively with learners as the process is built up together, checking understanding as we go; before,

You Do: Finally, checking the leaners can complete the process independently several times with success and understanding. By the end of this teaching sequence learners should have been prepared to now carry out the skill with complete independence. This high sense of achievement for the learner will lead to further motivation.

Releasing of teacher-responsibility during explicit instruction



2

Use Explicit Instruction for New Content

I Do

We Do

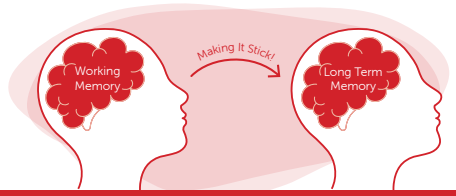
You Do

3

New Knowledge Needs to be Stored in the LTM, Ready for Retrieval and Transfer

Making It Stick!

Once the learner can carry out the process independently, it is the teacher's job to re-locate the learning into the learner's LTM. If the LTM is not affected then nothing has been learnt. We have to make the learning stick! The outcome of this is that the knowledge is now available for future retrieval and transfer.



Making It Stick! 5 Key Ideas

1. Keep doing it: Practice makes permanent!
2. Come back to it: Use gradually increasing time gaps to train the brain to retrieve the new knowledge (spaced practice). Include regular 'upkeep' checks and low-stakes testing, especially for key learning.
3. Mix it Up: Play around with this journey from WM to LTM, particularly by weaving in other learning in the gaps between practice sessions (interleaving).
4. Connect: As this 'new knowledge' becomes 'old knowledge' it is then used as an 'already fluent part' for more new knowledge (see example). We also connect this new knowledge to a bigger curriculum picture.
5. Increase Challenge/Transference: Guide learners to use the new knowledge with greater independence and in increasingly challenging and unfamiliar problems (expertise reversal).

Before Moving On:

Notice that as the new knowledge is beginning to transfer from WM to LTM, the teacher needs to employ different teaching strategies to maintain a correct cognitive load. This teacher-ability to guide learners through progressive curriculum content whilst retaining a manageable cognitive load is key. Generally speaking, the teacher withdraws their explicit instruction as learners practise, revisit and apply the new knowledge in increasingly challenging and unfamiliar contexts, and with greater independence.

Example of Connect

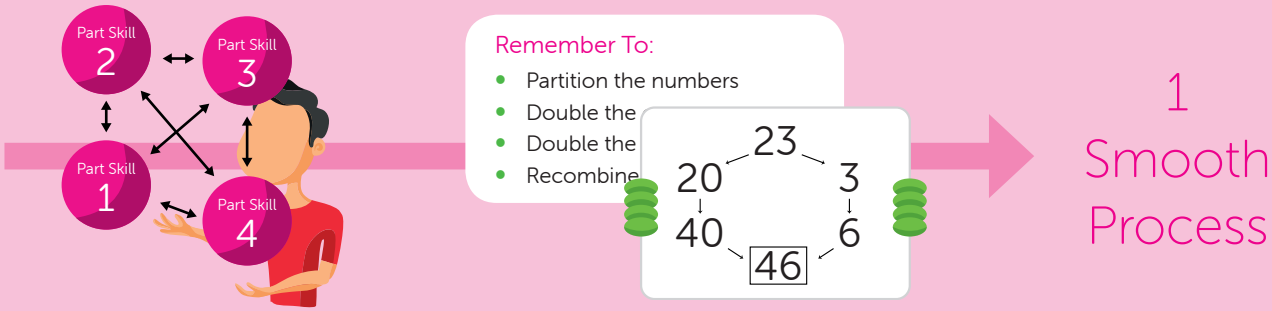
When the concept of multiplying with 10s (e.g. 3 x 40 = 120) is recently acquired, it is in danger of not being committed to the LTM.

However, using it again when connecting it to a progressive concept (e.g. 3 x 43) means the original concept is further strengthened in the LTM.

What is a schema? A schema is a word to describe how the LTM organises and holds information. Schemas are often a 'chunk' of separate pieces of knowledge (i.e. concepts, skills, facts) that the brain knits together into one single thought process. This helps the brain bring back a huge amount of knowledge very quickly when needed. The brain knits the parts together through pattern and meaning.

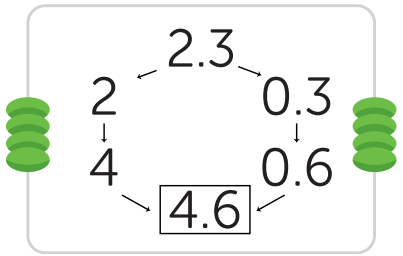
Example of Schema Formation

By knitting together the part skills of this doubling skill into one smooth process, a schema for doubling 2-digit numbers is formed.



How to Use a Schema:

Once the learner has a schema in their LTM, then, later on, we can lean on that one smooth thought process to extend the same concept into new skills without overloading the working memory; e.g. going on to double a 3-digit number, or a number with tenths, etc. In this way the schema grows and develops and connects with other schemas; this is learning!



Same Schema. New Skill

4

Learning Happens Through Schema Extension and Connection

4

Learning Happens Through Schema Extension and Connection

Before Moving On

Have a look at the image. It shows how at the point of learning to double a digit number for the first time the learner retrieved 4 already-fluent part skills so that their working memory wasn't overloaded;

i. Partitioning a 2 digit number

ii. Doubling a 1 digit number

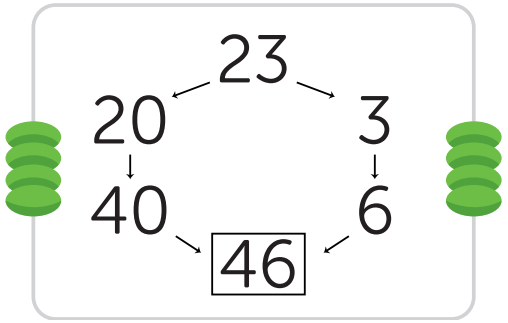
iii. Doubling a 2 digit multiple of 10

iv. Recombining a 2 digit multiple of 10 with a 1 digit number

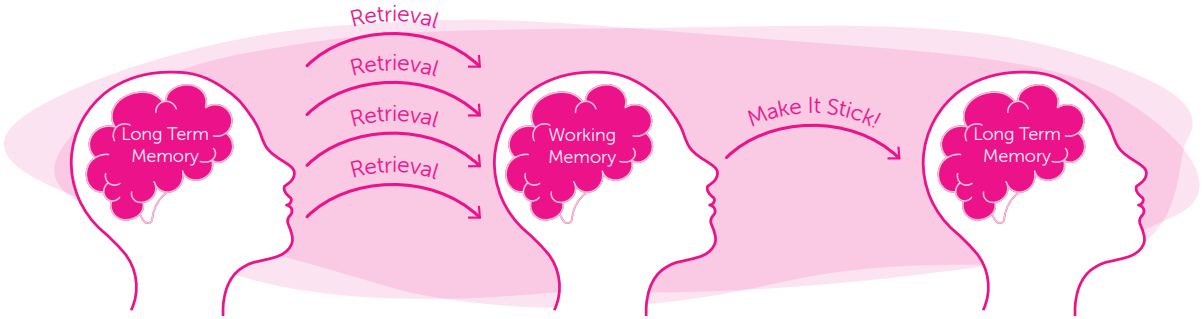
Then, as those skills were knitted into one smooth process, the learning moves into the long term memory ready for retrieval and transfer another day.

Remember To:

- Partition the numbers
- Double the ones
- Double the tens
- Recombine the numbers



Schemas held in the LTM connect in the WM; the new connection is then stored in the LTM



In order to ensure the working memory isn't overloaded, the teacher can break the bigger curriculum journey into smaller and smaller parts, and then present these smaller parts gradually to learners. It may seem like you are 'doing something' to the curriculum content, but in reality the content is as it is, you are merely zooming in to see the 'nature' of the content in more detail.

This 'zooming in' means you are seeing a lower intrinsic cognitive load to the new curriculum content, and, crucially, are ready to present this lower load to learners.

We can think of this aspect of the intrinsic load in terms of;

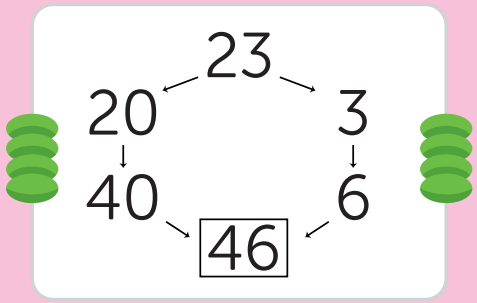
- how many parts (elements) we are expecting the working memory to deal with, and
- to what degree the parts are interdependent.

Example

If you were asked to mentally double three separate 1-digit numbers (e.g. 8, 4 and 7) and hold the answers, then there are three separate elements that the working memory is holding. However, if you were learning to double a 2-digit number for the first time then you have four elements, and the final one (recombining the numbers) is dependent on the earlier parts, and therefore presents greater load to the WM.

Remember To:

- Partition the numbers
- Double the ones
- Double the tens
- Recombine the numbers



5

Break the Curriculum Down Into Very Small Chronological Parts

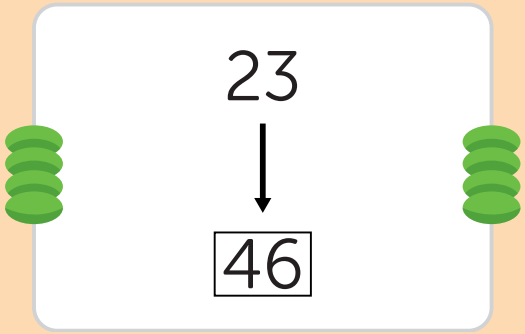
6

Know the Learner's Background Knowledge

Example

As we have seen, if you were learning to double a 2-digit number for the first time then you have four elements for the working memory to hold.

However, if this doubling is already a fluent schema in your LTM ('one smooth process'), then it is only one element. Merely continuing with this skill is cognitive underload. To maintain an effective cognitive load then the skill needs to be transferred into a new context (e.g. now doubling 423).



When the learner has relevant background knowledge they experience a lower intrinsic cognitive load for the same given piece of curriculum content.

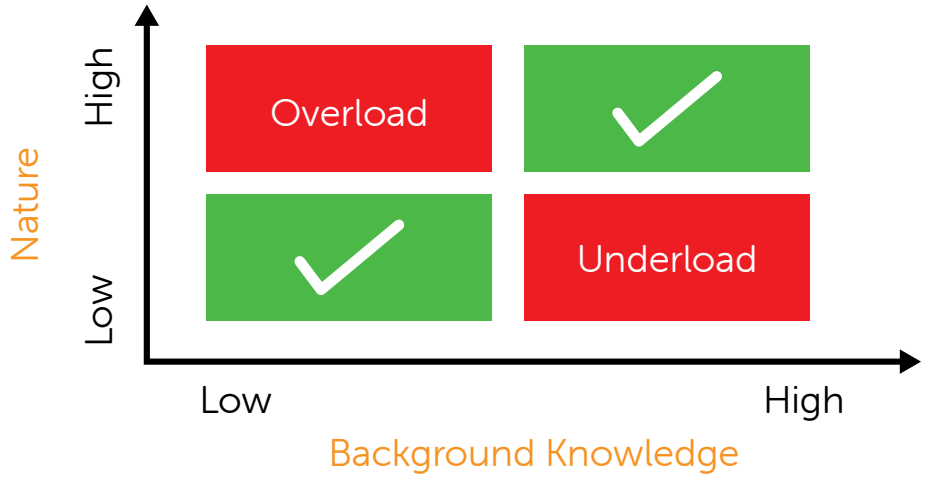
So, if we wish to present new content to learners with a manageable and productive cognitive load, then we need to balance the 'nature' of the cognitive challenge with the 'knowledge' that the learner brings. Taken together, this tells us the actual cognitive load that we plan to be placing on the learner's working memory. Notice how the 'nature' aspect is totally impersonal (it has nothing to do with the teacher or the learners) and the second aspect, 'knowledge', is totally personal! It is everything to do with the teacher and the learners, i.e. what schemas are in the individual learner's LTM and whether this is understood, and made use of, by their teacher.

Implications:

This means the teacher needs to know the curriculum content in great detail and know where their learners are cognitively placed along that detailed journey. This can soon become unmanageable for individual teachers but is made manageable through whole-school systems.

Since this booklet is an introduction to CLT, it is useful initially to see in general terms the interplay between the nature of the curriculum material (itself a combination of element quantity and interdependency) and the background knowledge the learner brings.

Notice that these considerations are all about the cognitive load that 'comes out of' (i.e. 'is intrinsic to') the curriculum/learner considerations when preparing, planning and adjusting teaching.



Before Moving On

It's also worth noting that our example of mentally doubling 3 separate numbers (e.g. 8, 4 and 7) provided the working memory with 3 discrete elements to process, whereas the example of learning to double a 2-digit number for the first time provided the working memory with 4 elements that had a degree of interdependency, and was therefore more challenging initially. However, we have also seen that these 4 elements can be brought together into 1 element ('one smooth process') because they relate to each other, whereas the 3 separate numbers have to stay as separate elements because they don't relate to each other. This helps reinforce our understanding of how a schema is created and extended, i.e. through the knitting together of relationships and pattern.

6

Know the Learner's Background Knowledge

7

Focus the Attention of Learners on the New Content... Only!

We started off by saying that the brain's working memory is very limited. It is easy to underestimate just how limited the working memory is. If we have applied the CLT planning and preparation principles just discussed - so that we are about to tax the learner's working memory to just the right degree and in just the right way - then it will all fall apart if learner attention is not directed on the actual new knowledge.

Don't think of this as a spotlight, or a torch; what we seek is the narrow laser-beam focus of the learner's attention on the learning...and nothing else! The learner is totally present and all distractions are absent. When the working memory is focused on learning (the construction or extension of schemas) then this is called the germane load.

The Oxford English Dictionary says...

Germane: relevant to a subject under consideration

Extraneous: irrelevant or unrelated to the subject being dealt with

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From this CLT perspective alone, we wish learners to be in class fully rested, suitably fed, emotionally secure and with impeccable behaviour. Some of these factors that interfere with attention are less easy to influence. The last thing a teacher wants to do is to take up valuable working memory capacity through their own teaching technique. When the teaching itself distracts from the learning by placing demands on the working memory that are not germane, this is called extraneous load.

Research

Research has shown that there are many subtle ways that the teacher can unwittingly direct attention away from the actual learning and create extraneous load on the working memory. Teachers can therefore respond through adjusting their instruction/teaching technique to minimise extraneous load and therefore have a positive effect on learning. Here are just a few:

The Modality Effect

This is where the teacher tries to avoid too much visual input (or too much auditory input) and distributes input between the two modes; for example by providing an image and narrating any accompanying messages/instruction (rather than providing accompanying messages/instruction in yet more text for the learner to process visually with the image).

The Split-Attention Effect

This is where the teacher can't avoid presenting an image and text together, hence the teacher is aware that they will provide less extraneous cognitive load if the image and text are integrated as one (as opposed to presenting them physically separated).

The Goal-Free Effect

This is where the teacher tries to avoid tasks where the learner just focuses on 'getting it right', but instead focuses on the process of getting it right and/or creates smaller learning goals that will lead to 'getting it right'.

The Transient Information Effect

This is where the teacher acknowledges that auditory input is soon lost to the past. When learners need to return to text, it should be in written form; generally short and simple.

The Redundancy Effect

This is where the teacher is conscious of any input that is simply not necessary for learning and is taking up valuable cognitive load. This can include new animations suddenly appearing that aren't relevant to the schema construction, or information that is provided repeatedly etc.

A Word of Caution

The messages here all come under the same principle of focusing the working memory on the learning only. However, there is little value in applying these approaches if the curriculum/learner considerations of managing appropriate intrinsic load at the planning/preparation stage have not already been dealt with. For example, no adjustment to visual inputs will rescue the learner that is destined to be underloaded (e.g. they are being taught to multiply 3 x 43 but can already multiply 3 x 43) or overloaded (e.g. they are being taught to multiply 3 x 43 but can't yet multiply 3 x 40 nor can recall 3 x 3).

Before Moving On

It is worth noting that some people feel the term 'germane load' isn't that helpful, even though in CLT it is usually one of the three cognitive load types.

It can be more practical to move forward from here just having discussions in school about managing intrinsic and extraneous loads to ensure learning takes place ('learning' being that the knowledge is freely available to the working memory, from the long term memory, for the purposes of retrieval and transfer).

7

Focus the Attention of Learners on the New Content... Only!

8

Teaching Becomes Redefined as 'Focussing, Guiding and Responding'

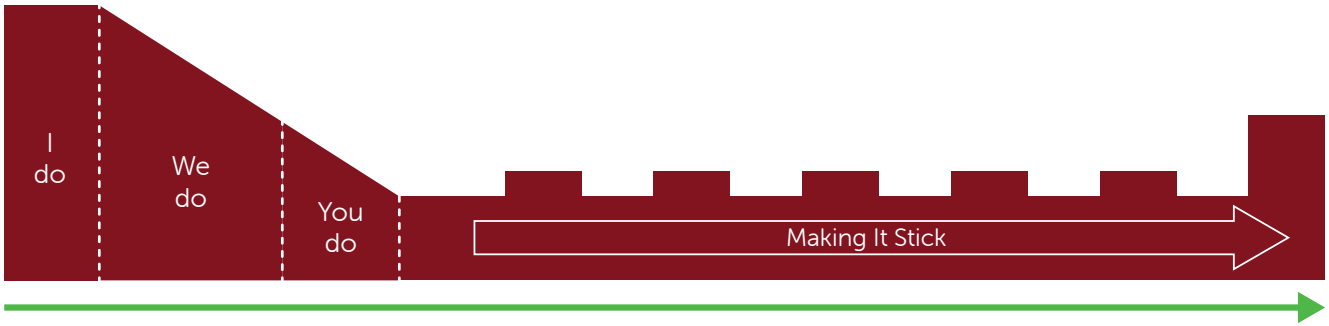
When we jigsaw together the key principles of CLT then we see a teacher that is knowledgeable about the human brain, understands that learning has only happened if a change in the LTM has occurred, and realises that such a change must be evidenced over time through a demonstration of retention and transfer of knowledge.

We see a teacher that has in front of them a curriculum learning journey that can be seen, not just in term of its larger structure, but also in smaller and smaller parts. The teacher has mapped the learner's background knowledge to this journey and is now ready to teach! The teaching strategies are dictated by the needs and limitations of the brain. If we join together the earlier CLT implications of 'explicit instruction' and 'making it stick', then we can see a teaching and learning episode that leaves the teacher with a role of:

- Focussing learners on schema construction and nothing else
- Guiding learners through a minimum (yet high) expectation curriculum learning journey, and
- Responding to learners' needs and adapting teaching accordingly as we go

It is this focussing, guiding and responding that, under CLT, becomes the new definition of what it means to teach!

Releasing and retaining teacher-responsibility



If we zoom into the 'Make It Stick' journey we see the teacher being able to leave learners to practise their new skills completely independently, and of course when an episode like that happens the teacher will want to just quickly check in that this practice session was effective/successful before leaving a time gap and coming back to it. These time gaps at first need to be quite close together as the brain consolidates the new skill.

Frequent low-stakes quizzes/tests are useful in these early days. However, the time between revisit sessions should continue to increase to the point where the learner has almost (but not quite) forgotten. As learners work harder to retrieve the skill, the schema gets stored more securely in the LTM. This is not easy to gauge, and again we can see why guiding and responding are at the heart of what it now means to teach.

Similarly, the teacher will seek to introduce other learning experiences into these time gaps to deliberately disrupt the retrieval; again so that the challenge to retrieve is greater. This interleaving can also be blended with increasing the challenge and varying the context that occurs when we do revisit the knowledge in question.

It is clear that this outward journey to perfect fluency can not be planned for with regards to timings and durations with any great conviction. The unspecified timings mean planning must be loose and adaptable. The teacher will have to feel it as they go; listening continually to their teacher voice.

8

Teaching Becomes Redefined as 'Focussing, Guiding and Responding'

8

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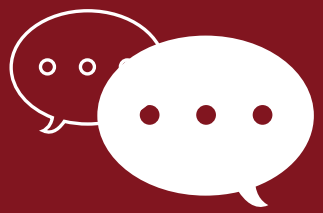
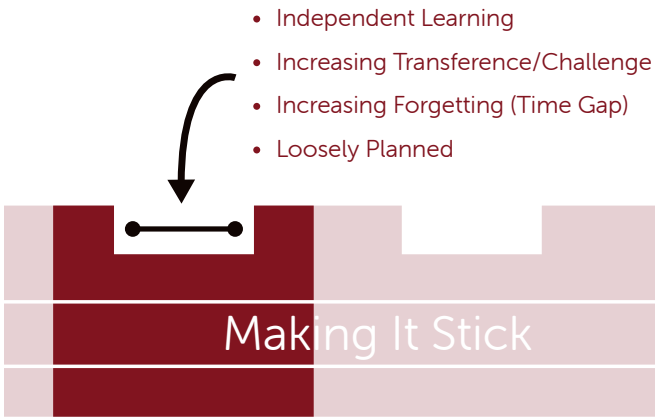
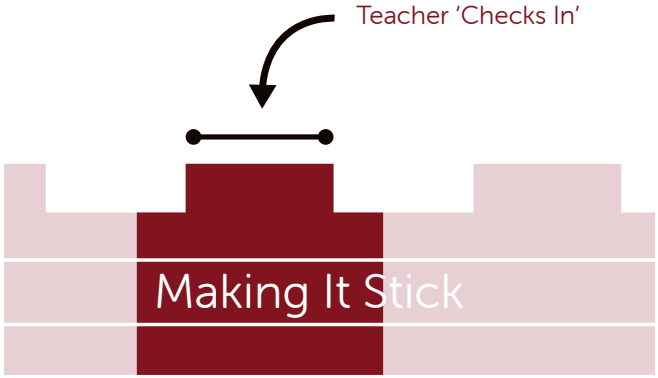
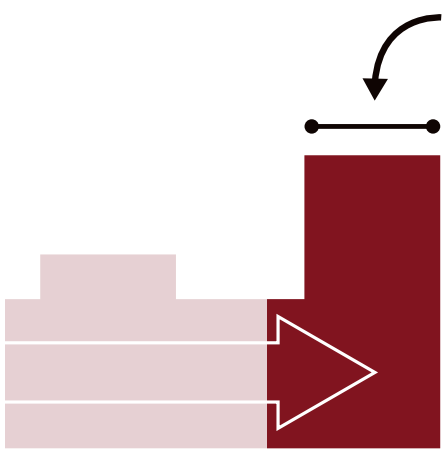




These raised sections signify times when the teacher touches base with the learner and their schema development. This engagement with the ‘make it stick’ process allows the teacher to respond to learners as they guide them along this outward journey.



Of course there comes an end point to this outward journey; here the teacher assesses in greater detail whether the original new knowledge has indeed been deeply embedded in the LTM. The larger time gaps will have proved the required retention is there, so this summing up is typically characterised by deeper learning challenges and problem solving.

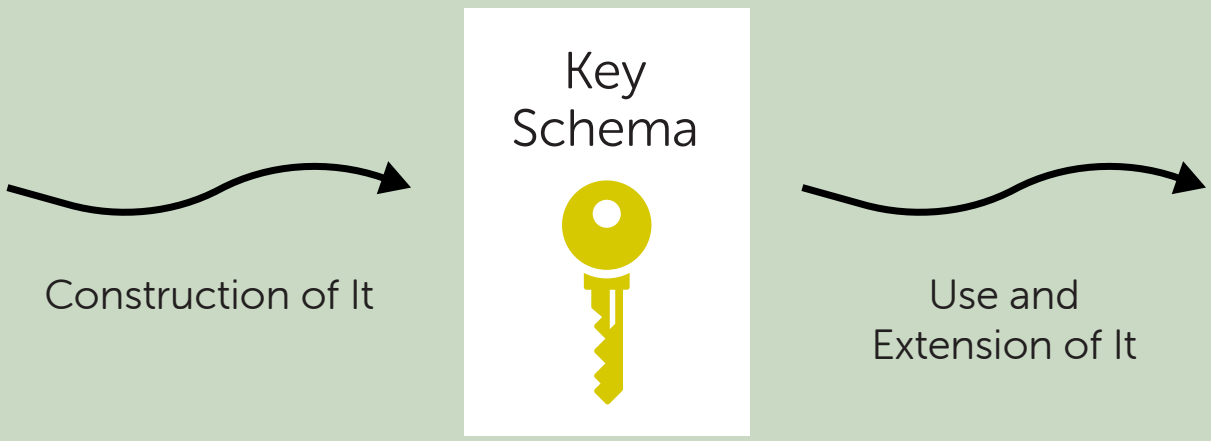


Not All Schemas Are Created Equally!

Whatever the subject or domain that you are interested in, it is important to have the pedagogical content knowledge of which schemas form part of the core curriculum content that are integral to success.

These key schemas are developed in the LTMs of learners over time, sometimes years, and are then used to unlock further key content over more time, again, sometimes years.

The identification, analysis and deconstruction of key schemas provide a school with clear learning goals to move all learners towards. Progress towards these schemas should be tracked especially carefully. Very often this learning goal, when reached (that is to say, 'this key schema, when constructed'), is a tipping point in the learner's fluency, and curriculum progress accelerates quickly from it. The schema is key because it is central to so much new knowledge that is to come. However, the good news is that every time the key schema is recalled to support new knowledge, then, not only does the learner make progress by acquiring the new knowledge, but the key schema is strengthened yet further. This can easily be seen in the working example that follows.



9

Identify the Key Schemas Operating Across the Bigger Learning Journey

9

Identify the Key Schemas Operating Across the Bigger Learning Journey

Example

When learning multiplication procedures at primary school, mastering the skill/concept of 1 digit x 2 digit whole numbers is the key schema. To prepare the learner's working memory to be cognitively ready, they need to be able to retrieve 4 multiplication facts from the x3 table and be able to apply these same four facts to the context of multiplying 10s.

Multiplication

Construction of It → Key Schema → Use and Extension of It

1d x 2d

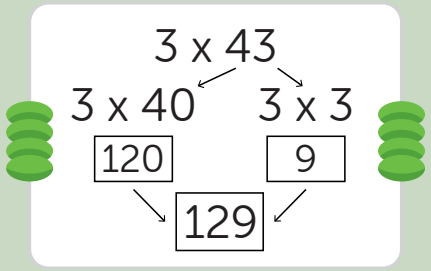
3 x 2	3 x 20
3 x 3	3 x 30
3 x 4	3 x 40
3 x 5	3 x 50

This allows us to teach the skill/concept through the learner's WM only requiring this information i.e. we can multiply any of these 16 numbers by 3 in our worked examples.

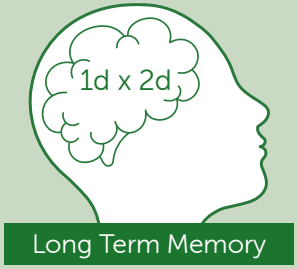
3 x	22	32	42	52
3 x	23	33	43	53
3 x	24	34	44	54
3 x	25	35	45	55

Remember To:

- Partition the 2d number
- Write out the 2 questions
- Multiply the ones
- Multiply the tens
- Add the part-answers to find the total



With only these reduced facts being used, the schema of 1d x 2d can be transferred to the LTM using the 'Make It Stick' ideas discussed earlier.



From this point onwards the 1d x 2d schema is used to unlock future multiplication as it is transferred into three new aspects of progression:

1

Same Schema, New Facts

→ We can now inject new facts into the same 1d x 2d process. This also provides a context for revisiting recently acquired multiplication facts e.g. the x4 table, x8 table etc →

4 x 43
8 x 37
7 x 74

2

Same Schema, New Skill

→ We can now bolt a new part-skill onto the same 1d x 2d process. For example, first multiplying 1d x 2d as one smooth process, then multiplying the hundreds and recombining. →

3 x 243 is '3 x 43' then '3 x 200'

3

Same Schema, New PVQs

→ We can also transfer this to other PVQs (place value quantities). For example, we can transfer this to tenths (3 x 2.43 can be thought of as 3 x 43 hundredths, and then 3 x 2). In this way learners can easily calculate multiplications to 2dp using the one original 1d x 2d schema. →

3 x 0.43 is '3 x 43' then recall that they're hundredths, i.e. 1.29

9

Identify the Key Schemas Operating Across the Bigger Learning Journey

10

Systemise CLT Across the School to Maintain CLT Principles and Reduce Workload

Cognitive Load Theory comes with a health warning; if you continue to break down the curriculum into smaller and smaller parts, and match each learner up against those parts, you may just drown in an amount of information that your own working memory can't process! Yet, at the same time, CLT principles remain true.

Basic logic takes us to a realisation that a single isolated teacher is somewhat limited in their implementation of CLT. There needs to be a whole-school systematic approach; a curriculum designed entirely around the principles of CLT. What would that look like?

Here are 5 key features of a CLT-driven curriculum design.

i) Curriculum Content Detail

Firstly, the breaking down of the learning journey into small parts needs to happen just once, from start to finish, in a well thought out manner that takes account of the domain specific journey to fluency that learners are typically on.

All of the detailed minutia can be in place at the design stage, so that a teacher never needs to spend time deconstructing the curriculum for themselves, rather this detail is immediately accessible (i.e. in an online digital format) so that the teacher has less workload, not more.

This curriculum understands that constructing schemas transcends year groups. Where schemas connect to each other, the curriculum chronology must ensure learners 'turn up' to lessons with the pre-requisite background knowledge.

The successful following of this learning journey will prevent the crippling inefficiency teachers experience when they need to constantly check for, and perhaps suddenly find, learning gaps.

ii) The Expected Journey

Secondly, running through this curriculum journey there must be a timeline that describes a minimum, yet high, expectation for all learners (without a relevant learning difficulty) to acquire core knowledge. This allows teachers across the school to keep a large group together for explicit teaching of core knowledge, thus maintaining a correct cognitive load for the class, whilst reducing workload for teachers. The key point here is that this large cohort group will have a predictable background knowledge, as opposed to an unknown one. The actual standard of this minimum, yet high, expectation journey will be driven by a combination of;

- the research evidence available that identifies what children can reasonably be expected to achieve at a given age,
- the national/global age-related expectations, and
- the school's individual ambition and identity.

This connecting of the core knowledge curriculum content to an expected timeline, happens at all levels of time considerations. Learners are expected to be kept 'on track' across a year, a term, a week, a lesson etc...

iii) Adaptive Teaching

Thirdly, from this core journey the teacher may/ will need to adapt their teaching input to allow for the varying needs of learners.

There are 3 general modes of adaptive teaching:

a) Adapting teaching for those learners below the expected journey:

The time frame consideration here is short only. These learners are 'off track in the moment'. Teaching still needs to build on their personal background knowledge, and the teacher will know this before 'the moment', and can therefore plan to adapt input out of consideration for those individuals and the specific content of the moment. There are no long term 'low ability' groups. Learners would only be off track in the moment if they are experiencing a relevant learning difficulty or have not been part of this curriculum design (e.g. they may suddenly arrive from another school, or the school may be starting to implement this curriculum).

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b) Adapting teaching after explicit instruction:

We have seen that providing worked examples through direct instruction supports the principles of CLT. In a CLT-driven curriculum journey, a large group of learners within a class will come to be 'cognitively ready' for this input together. Once the direct input is complete, learners will move along an outward journey to fluency. We have already seen that the teacher focuses learners, guides learners and responds to learners throughout. This is now accentuated as the teacher guides learners in a more personalised way along the outward journey. Typically, more able learners within this large group will move outward more rapidly, and spend more time in the deeper learning challenges of;

- problem solving,
- connecting the knowledge to a bigger curriculum picture, and
- transference into cross-curricular and real-life contexts.

Crucially, the large group will be brought together at the end of this learning sequence (regardless of how far along the outward journey they travelled), ready for a common direct input on the next progressive step of core knowledge; thus maintaining a managed spread and managed teacher workload at all times

c) Adapting teaching for those learners ahead of the expected journey:

This mode of adaptive teaching is almost identical to the first, except, this time, specific learners are ahead of the core knowledge acquisition journey. The key point being, even the extension into more challenging material described above provides insufficient cognitive load for these individuals in this particular aspect of learning. Again, there are no long term 'high ability' groups. This bespoke adaption only arises out of considering the precise individuals and the curriculum content of the moment.

A Nuanced Point

When adapting teaching for multiple learners that are below, or ahead of, the expected journey (a and c above), then the principles of providing input centrally and then adapting teaching as a response to guiding learners outwards along the 'make it stick' journey (from b above) should be applied.

Implementation Errors

When first implementing this CLT-driven curriculum, then, in many cases, there will be a large spread of ability in a single class. The principles of adaptive teaching will not immediately be effective, and should only be loosely applied as other techniques are used to eliminate the unmanaged spread and bring it into line as a managed spread ready for adaptive teaching.

Implementation errors can spring from not appreciating that adaptive teaching won't be immediately effective and will need to evolve through the implementation process. One error is the false mindset of 'this won't work and we need to return to the fixed ability groupings of differentiation'. A second error is to immediately start providing input to one large group within the class as if they were all ready for a common input, when they are not.

This is in breach of CLT principles and can lead to slowing progress for many learners.

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iv) Tracking of Key Content/Schemas

Associated with this curriculum design is a school's internal tracking system that takes the key learning steps, the core content, and the crucial schemas, and maps these into a system that guides all learners along the minimum, yet high, expectation journey.

This tracking system is the tool that gives teachers the confidence to carefully implement instruction with appropriate cognitive load, without needing to continually be checking each learner against every element themselves. For this to happen, the system needs to have an 'alert' feature built in, so that any learning gaps that do arise can be identified and responded to immediately.

This tracking system needs to be state of the art if it is to be responsive in this way. It must be fit for the new age of teaching, i.e. it should be an online system that is engaging and motivating for learners, yet immediately alerts the teacher to any potential learning gap developing with zero workload other than the response itself.

This tool also provides the continual low-stake quiz/testing that we could also think of as 'retrieval practice'.

v) School Leadership

Finally, as we go deeper here with the implications of CLT, we see a strengthening of the teacher's role as being to focus learners, guide learners and to respond to learners. This **is** adaptive teaching and it has many knock-on implications for school leaders. The need to design such a detailed and nuanced curriculum journey requires great expertise and time.

Resources need to be instantly adaptable (again, probably digital) and numerous, if they are to support adaptive teaching at this level. The system that tracks key content providing effort-free alerts provides the school leader with a transparency to see the impact of the curriculum at a glance, and it empowers the school leader to go straight into the curriculum detail of any issue.

In itself this returns school leaders to leading teaching! However this time there is a difference, the school leader is leading CLT-driven adaptive teaching.

Reference

Sweller, J., Ayres P. and Kalyuga S. (2011). Cognitive Load Theory: Explorations in the learning Sciences, Instructional Systems and Performance Technologies (New York: Springer)

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