

Operationalizing Cognitive Load Theory for Students with Learning Disabilities: A Phase-Based Instructional Design Framework

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ABSTRACT

*Students with learning disabilities (LD) often struggle in reading, writing, and mathematics. A large part of this struggle comes from how they process information; specifically, the limits of their working memory (WM). When instruction does not account for these limits, learning breaks down, regardless of how skilled the teacher is. Cognitive Load Theory (CLT) explains why this happens. It describes three types of cognitive load which effect learning: intrinsic load (task complexity), extraneous load (poor design), and germane load (the effort that builds real understanding). CLT has influenced many teaching strategies, but it has rarely been developed into a structured, step-by-step process; especially for LD students. This article addresses that gap. It presents a phase-based instructional design framework that translates CLT into three actionable phases: managing intrinsic load, reducing extraneous load, and fostering germane load. Unlike prior applications of CLT, this framework introduces a novel element: a cognitive load audit step embedded within each phase that prompts designers to explicitly check load conditions before moving forward. This makes the process systematic rather than intuitive. The framework is grounded in both CLT and research on cognitive processing in LD students. It is adaptable across subjects and age groups, and it is designed to be used by researchers, intervention designers, and classroom teachers alike. The article also presents testable propositions and discusses implications for future research and practice.*

**Keywords:** *cognitive load theory, working memory, learning disabilities, instructional design, special education, phase-based framework*

INTRODUCTION

LD students face persistent difficulties in school. Reading, writing, and math are the areas most commonly affected, and these problems do not simply go away with better teaching or more effort (Rogers et al., 2020). Research points to something more fundamental: the way these students process information is different. Specifically, they tend to have limited working memory (WM) capacity; and this limitation shapes how much they can learn at any given moment (Swanson, 2015).

WM is the part of our cognitive system that holds and manipulates information while we are actively using it. It is small, fast, and easily overloaded. When instruction places too many demands on it at once, learning suffers; not because the student lacks ability, but because the cognitive system simply cannot keep up (Mähler & Schuchardt, 2016).

Cognitive Load Theory (CLT) was developed precisely to explain this phenomenon. It argues that learning outcomes depend heavily on how well instruction manages the demands placed on WM (Sweller & Chandler, 1991; Sweller, 2011). CLT identifies three types of cognitive load: intrinsic load, which comes from the complexity of the content itself; extraneous load, which comes from how information is presented; and germane load, which reflects the mental effort that actually builds understanding and long-term memory

(Klepsch & Seufert, 2020). These distinctions have generated a range of practical teaching strategies, from worked examples to spaced sequencing to eliminating visual clutter (Fraser et al., 2015).

More recently, researchers have begun applying CLT specifically to LD students (Bishara, 2022). This makes sense. These students tend to expend more cognitive effort on basic operations; sounding out words, recalling math facts, forming letters; which leaves less mental capacity for higher-order thinking. They are, in a sense, running their cognitive systems at a higher baseline load than their peers. Even small increases in task complexity or poorly designed materials can push them past their limit (Kennedy & Romig, 2021).

The problem is that CLT, despite its theoretical richness, has not been translated into a clear, usable design process. Researchers have identified what works in broad terms, but they have not shown exactly how to sequence those decisions; especially for educators working with students who have LD. This gap matters. In special education, small design choices can have large consequences. A task that is slightly too complex, or a worksheet that splits attention across the page, can mean the difference between learning and frustration.

This article addresses that gap directly. It presents a phase-based instructional design framework that turns CLT into a practical, sequential process. The framework has three phases; managing intrinsic load, reducing extraneous load, and fostering germane load; and it introduces a novel cognitive load audit checkpoint within each phase. This audit mechanism distinguishes the framework from prior CLT applications, which have generally left practitioners without a way to systematically verify whether load conditions have been met before moving to the next design step.

The framework makes three main contributions. First, it operationalizes CLT by organizing its principles into a step-by-step design process; something previous work has not provided. Second, it anchors that process explicitly in the cognitive profile of LD students, particularly their reduced functional WM capacity. Third, it introduces a structured audit mechanism that makes the design process verifiable and replicable, not just conceptually sound.

The sections that follow describe the conceptual approach, review the theoretical foundations, position the framework within existing models, explain each phase in detail, illustrate its application across academic domains, and propose directions for future research.

## **CONCEPTUAL APPROACH**

### **Nature of the Approach**

This article uses a conceptual synthesis methodology. It does not present new empirical data or a formal systematic review. Instead, it draws on established findings from CLT (Paas et al., 2003) and from research on cognitive processing in LD students (Fletcher et al., 2018), and it integrates these into a coherent design model. This approach is well suited to the current state of the field, where substantial knowledge exists across two bodies of literature that have rarely been brought together in a structured way.

### **Sources of Theoretical Integration**

The framework draws from two main sources. The first is CLT; particularly its three-load model and the instructional principles derived from it (Orrù & Longo, 2019). The second is research on the cognitive characteristics of LD students, especially findings about WM constraints and domain-specific learning challenges (Peng et al., 2017). By integrating these two sources, the framework remains theoretically grounded while staying responsive to the real learning needs of this population.

### **Framework Development Process**

The framework was developed in three steps. First, the key principles of CLT were examined for their instructional implications; specifically, how intrinsic, extraneous, and germane load can each be influenced by design decisions. Second, those principles were evaluated in light of what is known about WM constraints in LD students. Third, the findings were organized into a sequential, phase-based structure. Critically, a cognitive load audit checkpoint was added to each phase; a feature derived from quality assurance thinking in instructional systems design; to ensure that load conditions are explicitly verified at each stage before moving forward.

### **Scope and Intended Use**

The framework is a thinking tool, not a rigid prescription. It does not specify which materials to use or dictate a single teaching method. Instead, it provides a structured way to think through design decisions. The same principles can be applied differently depending on the subject, the student's age, and the educational context. It is intended primarily for researchers, intervention designers, and teachers involved in creating or evaluating instructional materials for LD students, though it may also inform broader curriculum and lesson planning work.

### **Limitations of the Approach**

This framework is a theoretical model, not an empirically validated intervention. Its propositions require testing. Like any conceptual synthesis, it reflects choices about which evidence to emphasize, and alternative interpretations of the same literature are possible. The framework also does not fully account for factors like motivation, emotion, or the social environment; all of which influence learning. It should be understood as one component of a larger picture, not a complete theory of instruction.

## **THEORETICAL FOUNDATIONS**

### **Cognitive Load Theory**

CLT begins with a straightforward observation: learning depends on WM, and WM has severe limits (Sweller, 2023). It can hold only a few pieces of information at a time, and it loses those pieces quickly if they are not actively maintained. When instruction ignores these limits; by presenting too much information at once, or by designing tasks that force unnecessary mental effort; learning breaks down (Sweller & Chandler, 1991).

CLT describes three types of cognitive load, each with a different source and a different relationship to learning. Intrinsic load comes from the content itself. It reflects how complex the material is and how many elements must be understood simultaneously (Endres et al., 2023). Extraneous load comes from how the content is presented. Poorly designed materials; split-attention layouts, redundant information, cluttered visuals; all add to extraneous load without contributing to learning (Çakıroğlu & Aksoy, 2017). Germane load is the cognitive effort that is productive: the effort that goes into building understanding, making connections, and forming schemas that can be retrieved and applied later.

It is worth noting that germane load has been debated in recent CLT literature. Sweller (2010) and others have questioned whether germane load should be treated as a distinct category, or whether it is better understood as the portion of available WM capacity that is directed toward schema construction (Greenberg & Zheng, 2023). This framework takes a pragmatic position: rather than treating germane load as a fixed quantity to be maximized, it treats it as the productive use of whatever cognitive capacity remains after

intrinsic and extraneous loads have been managed. This is consistent with current thinking in the field and avoids the conceptual difficulties that arise from treating all three loads as independently additive.

The practical upshot is three design goals: regulate intrinsic load by managing task complexity, reduce extraneous load by cleaning up presentation, and support germane load by creating conditions for deep processing. These goals are well established in the CLT literature. What has been missing is a clear process for pursuing all three in a coordinated, sequential way; especially for students whose cognitive resources are already stretched thin.

### **Cognitive Processing in Learning Disabilities**

LD students have smaller functional WM capacity than their peers; not because their cognitive architecture is fundamentally different, but because basic operations demand more effort from them (Moll et al., 2016). A student who struggles to decode words uses WM resources on decoding that a fluent reader uses for comprehension. A student who cannot quickly recall math facts must use WM to compute them, leaving less capacity for problem-solving. This pattern appears across domains: reading, writing, mathematics, and beyond.

The concept of diminished functional WM capacity is important because it reframes the problem. These students are not less intelligent. They are running at a higher cognitive baseline. Instruction that would be manageable for a typical learner can be overwhelming for a student with LD, simply because their available capacity is already being consumed by lower-level processes.

This is why instructional design matters so much in special education. When materials are cluttered, tasks are poorly sequenced, or demands are misaligned with student ability, the cognitive system gets overwhelmed before any meaningful learning can happen. Careful design is not optional for these students; it is the precondition for learning.

### **Implications for Instructional Design**

Bringing CLT and LD research together produces three clear design imperatives. First, intrinsic load must be managed carefully. Tasks should be aligned with the student's current ability level; not so easy that they are unchallenging, but not so complex that they exhaust cognitive resources before understanding can develop. Second, extraneous load must be minimized. Every element of an instructional material that does not contribute to learning is a tax on limited cognitive resources. Third, germane load must be actively supported. This means designing activities that push students to process content deeply, make connections, and practice applying their knowledge; but only once the first two conditions have been met.

This framework translates these three imperatives into an explicit, auditable design process. The next sections explain how.

### **Positioning within Existing Frameworks**

Several instructional frameworks address the design of learning experiences. The most relevant are CLT itself, the Four-Component Instructional Design model (4C/ID), explicit instruction, and Universal Design for Learning (UDL). Each has genuine strengths, but each also has limitations; particularly when applied to the specific challenge of designing instruction for LD students.

CLT provides the theoretical foundation for understanding how cognitive load affects learning (Sweller, 2011; Sweller, 2023). Its principles are well supported empirically, and they translate into practical

strategies like worked examples, sequential task design, and attention to visual layout. But CLT is primarily a descriptive theory. It explains what to think about when designing instruction. It does not offer a sequential process for actually doing the design work, and it does not address the specific cognitive profile of LD students.

The 4C/ID model is more procedural (Costa et al., 2022; van Merriënboer et al., 2024). It organizes instruction around four components; whole tasks, supportive information, procedural information, and part-task practice; and it provides a structured approach to managing task complexity. It is well suited to complex skill learning, and it takes cognitive load seriously. However, 4C/ID was developed for general learners. It does not directly engage with the reduced functional WM capacity that characterizes many LD students, and it does not include a mechanism for auditing whether cognitive load conditions have been met at each design stage.

Explicit instruction involves direct teaching, modelling, guided practice, and a gradual release of responsibility to the student (Hughes et al., 2017; Hughes et al., 2022). It has strong empirical support in special education. But explicit instruction is a pedagogical approach, not a design framework. It describes how to teach, not how to analyse and manage cognitive load during the design process. It is consistent with CLT principles, but it does not make those principles explicit or systematic.

UDL aims to make learning accessible to all students by offering multiple means of engagement, representation, and action (Capp, 2017; Al-Azawei et al., 2016). It emphasizes flexibility and inclusivity. But UDL focuses on access and variability, not on cognitive load. It does not provide tools for analysing how instructional decisions affect WM demands, or for systematically managing those demands across the design process.

The framework presented in this article is designed to complement these existing approaches, not replace them. It fills a specific gap: a structured, phase-based design process that translates CLT principles into sequential decisions, explicitly accounts for the cognitive profile of LD students, and includes a built-in audit mechanism to verify load conditions at each stage. Table 1 summarizes the comparison.

**Table 1: Comparison of Instructional Frameworks**

Framework	Primary Focus	Strength	Limitation	Contribution of Present Framework
CLT	Cognitive principles	Strong theoretical base	Not procedural	Operationalizes into auditable phases
4C/ID	Complex skill design	Structured sequencing	Not LD-specific	Adds LD-focused cognitive load audit
Explicit Instruction	Pedagogy	Strong empirical support	Limited cognitive mechanism	Provides cognitive design logic
UDL	Accessibility	Addresses variability	Not load-focused	Adds cognitive load structure

## **OPERATIONALIZING CLT: A PHASE-BASED FRAMEWORK**

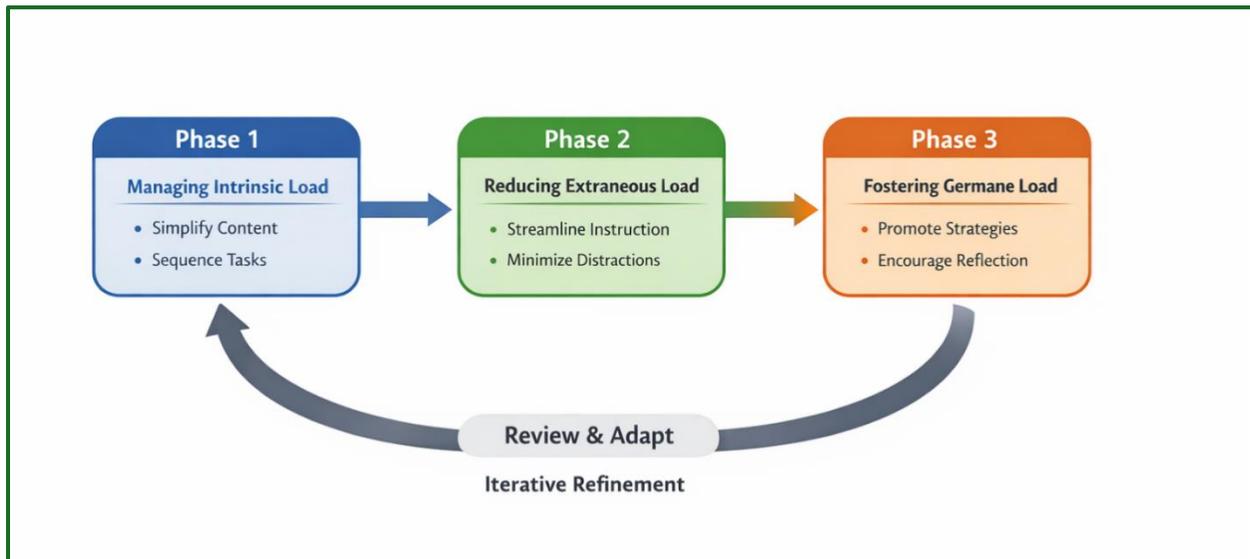
### **Overview**

The framework organizes CLT into three sequential phases, each corresponding to one type of cognitive load. Phase 1 addresses intrinsic load, Phase 2 addresses extraneous load, and Phase 3 addresses germane

load. Within each phase, designers make specific decisions about task structure, content presentation, or learning activity design. After each phase, a cognitive load audit checkpoint prompts the designer to verify that the phase's goal has been achieved before moving on.

This audit mechanism is the key innovation of the framework. Previous applications of CLT have provided lists of strategies or broad design principles, but they have not given practitioners a way to check their work systematically. The audit checkpoint closes this gap by embedding a verification step into the process itself. The phases are shown sequentially, but the framework is designed to be iterative. If audit results at any phase reveal problems, earlier decisions should be revisited and revised.

**Figure 1: The Phase-Based Framework**



### Core Assumptions

The framework rests on three assumptions. First, WM capacity constrains learning, and for LD students, that constraint is tighter than average because basic cognitive operations demand more effort. Second, instructional design decisions; about task complexity, material presentation, and activity type; directly influence how much cognitive load students experience. Third, all three types of cognitive load must be managed together. Reducing extraneous load does not help if intrinsic load is already overwhelming, and fostering germane load is impossible if the first two have not been addressed.

### Phase 1: Managing Intrinsic Load

The first phase focuses on the task itself. Intrinsic load reflects how complex the material is; how many elements it contains and how those elements interact. For LD students, even moderate complexity can be overwhelming if it is not carefully managed.

The design work in this phase begins with task analysis. The designer breaks the task into its component parts and examines how those parts relate to each other. Some components can be learned independently; others must be understood together. Identifying this structure allows the designer to sequence content effectively; from simpler to more complex, with foundational skills established before more demanding ones are introduced.

Part-task training is particularly useful here. When a task has components that are especially demanding; like letter formation in writing, or basic fact retrieval in math; those components can be practiced separately until they become more automatic. This frees up WM for higher-level aspects of the task.

Activating prior knowledge is another important strategy in this phase. New content is easier to process when it connects to something already known. Designers should think about what students already understand and create bridges between that knowledge and the new material.

*Cognitive Load Audit - Phase 1:* Before moving to Phase 2, the designer should ask: Is the task complexity aligned with the student's current ability? Have I identified which components can be taught separately and which must be learned together? Is there a clear sequence from simpler to more complex? If the answer to any of these questions is no, the phase should be revisited.

### **Phase 2: Reducing Extraneous Load**

The second phase focuses on how content is presented. Extraneous load does not come from the task itself; it comes from design decisions that make the task harder to process than it needs to be. For LD students, this type of load is particularly damaging because it consumes the limited WM capacity they need for actual learning.

The most common sources of extraneous load are split attention, redundancy, and visual clutter. Split attention occurs when students must look back and forth between separate sources of information; a diagram on one side of the page and a description on the other, for example. Integrating related information into a single, coherent presentation eliminates this problem.

Redundancy occurs when the same information is presented in multiple formats simultaneously; both read aloud and displayed as text, when one would suffice. While using both visual and auditory channels can be helpful (the modality effect), presenting identical information in both is counterproductive.

Visual clutter; irrelevant images, decorative elements, excessive text on a single page; adds extraneous load without adding learning value. Materials should be clean, focused, and stripped of anything that does not contribute to understanding.

Worked examples are especially useful in this phase. When students can see a complete, correctly worked solution, they do not have to use WM to figure out the process while also trying to understand the content. As students build competence, worked examples should be gradually faded; replaced by problems with increasing gaps; to support the transition to independent practice.

*Cognitive Load Audit - Phase 2:* Before moving to Phase 3, the designer should ask: Is all related information integrated into a single, clear presentation? Have I eliminated redundant content? Are materials free of irrelevant visual elements? Do worked examples demonstrate the process clearly and completely? If not, revise before proceeding.

### **Phase 3: Fostering Germane Load**

The third phase focuses on learning activities; the tasks students actually do to build understanding and develop transferable knowledge. This phase is only effective once Phases 1 and 2 have been addressed. If intrinsic load is still too high or extraneous load has not been reduced, students cannot direct their cognitive effort toward meaningful learning.

Consistent with the current understanding of germane load as the productive use of available capacity; rather than a fixed, additive quantity; this phase is about creating the conditions under which students can use whatever cognitive resources they have for deep processing (Greenberg & Zheng, 2023).

Example fading is one of the most effective strategies here. Students begin with fully worked examples, then move to partially completed problems, then to independent problem-solving. This gradual withdrawal of support encourages deeper engagement without overwhelming students.

Self-explanation is another powerful tool. When students articulate why a step works, or how a new concept connects to something they already know, they process the content more deeply than when they simply read or observe. Designing activities that prompt self-explanation; through questions, structured reflection, or paired discussion; supports schema formation.

Varied practice matters too. Students need to apply their knowledge across different contexts and problem types, not just repeat the same task. This kind of variability is what produces flexible, transferable understanding; the ability to use knowledge in new situations, not just in the context where it was learned.

Metacognitive prompts; questions that ask students to think about their own thinking; can also strengthen learning. Asking students to identify where they got confused, or to explain what strategy they used and why, builds the kind of self-awareness that supports independent learning over time.

*Cognitive Load Audit - Phase 3:* After designing learning activities, the designer should ask: Do activities require students to actively process content, or just passively receive it? Is there a clear progression from supported to independent practice? Do activities vary sufficiently to build transfer? Are students prompted to reflect on their own understanding? Revise as needed.

**The Iterative Nature of the Framework**

The three phases are presented in order, but real instructional design is rarely linear. Student responses during piloting or implementation often reveal problems that were not visible during initial design. A student who struggles during Phase 3 activities may be signalling that the task is still too complex (a Phase 1 issue) or that the materials are still too cluttered (a Phase 2 issue). The audit checkpoints are designed to catch these problems before they affect learning; but if they are missed, the framework supports revisiting and revising earlier decisions.

This iterative quality is important. It means the framework is not a one-time checklist but a design cycle; one that designers return to as they learn more about how students are responding to the instruction.

**Summary of the Framework**

Table 2 summarizes the three phases, their focus, goals, design actions, and audit questions.

*Table 2: Summary of the Phase-Based Framework*

Phase	Focus	Primary Goal	Key Design Actions	Audit Question
1	Intrinsic Load	Align task complexity with student capacity	Task analysis, sequencing, part-task training, prior knowledge activation	Is complexity aligned with current ability? Is sequencing clear?

2	Extraneous Load	Eliminate unnecessary cognitive demands	Integrate information, reduce redundancy, remove clutter, use worked examples	Are materials clean and integrated? Have unnecessary demands been removed?
3	Germane Load	Create conditions for deep processing and transfer	Example fading, self-explanation, varied practice, metacognitive prompts, feedback	Do activities push deep processing? Is there a progression to independence?

### ILLUSTRATIVE APPLICATIONS ACROSS DOMAINS

The same three-phase logic applies across academic subjects, though it looks different in each one. The following examples illustrate how the framework operates in mathematics, reading, handwriting, and written composition.

#### Mathematics

Math problems often involve multiple interconnected steps; understanding a concept, applying a procedure, and manipulating symbols, often simultaneously. This combination places heavy demands on WM, which is exactly where LD students are most vulnerable.

In Phase 1, the designer breaks the problem into its components. Can number facts be practiced separately from multi-step procedures? Should simpler problem types precede more complex ones? Is the student's prior knowledge of relevant concepts sufficient, or does it need to be built first? These questions shape how the task is introduced and sequenced.

In Phase 2, the designer focuses on presentation. Problem statements, diagrams, and solution steps should appear together; not on separate pages or in separate columns. Worked examples should show the complete solution process without extraneous commentary. The page should be clean, with no decorative elements competing for attention.

In Phase 3, students gradually take over the problem-solving process. Worked examples are faded, replaced by problems with increasing gaps. Students are asked to explain their reasoning, not just produce answers. Practice problems vary in type and context to build transferable understanding.

#### Reading

Reading presents a particular challenge for LD students because it involves two cognitive tasks simultaneously: decoding (translating print into words) and comprehension (making meaning from those words). For many LD students, decoding is effortful and slow, which leaves little capacity for comprehension.

In Phase 1, text complexity is calibrated to the student's current decoding ability. Texts that are too difficult force students to use all their WM on word recognition, leaving nothing for meaning-making. Prior knowledge activation; brief discussion or preview before reading; reduces the cognitive effort needed to make sense of the content.

In Phase 2, the text itself is formatted clearly. Fonts are readable, line spacing is generous, and there are no irrelevant images or sidebars competing for attention. Vocabulary support; definitions or visuals; is placed adjacent to the relevant text, not in a separate glossary.

In Phase 3, comprehension activities require students to process the text actively. Summarizing, drawing inferences, connecting the text to prior knowledge, and discussing what they read all push students to engage more deeply with the content than passive reading alone.

### **Handwriting**

Handwriting is often underestimated as a cognitive task, but for students with motor difficulties, it can consume a significant portion of WM capacity. Concentration on forming letters leaves little room for thinking about what to write.

In Phase 1, instruction focuses on individual letters or strokes before moving to words and sentences. This reduces task complexity by isolating the most demanding component until it becomes more automatic.

In Phase 2, models are clear and consistent. The designer provides a single, unambiguous example of each letter, without decorative variations that might confuse. Practice materials are uncluttered; lined paper without distracting patterns, with clear models positioned where students can easily reference them.

In Phase 3, practice builds fluency progressively. As letter formation becomes more automatic, the focus shifts toward using handwriting for real communication; notes, short responses, creative writing; so that the skill connects to meaningful purpose.

### **Written Composition**

Writing is arguably the most cognitively demanding of the four domains. It requires idea generation, organization, sentence construction, word choice, spelling, punctuation, and handwriting; often simultaneously. For LD students, this combination is routinely overwhelming.

In Phase 1, the writing process is broken into stages. Planning, drafting, and revising are treated as distinct activities, not one continuous task. Graphic organizers or structured outlines help students manage the planning stage without having to hold the entire piece in WM at once.

In Phase 2, instructions are clear and minimal. Examples of strong writing at an appropriate level are provided so students understand the target without having to guess. The writing environment; whether physical or digital; should be free of irrelevant stimuli.

In Phase 3, students are prompted to think about their audience, evaluate their own writing against explicit criteria, and revise based on specific feedback. These activities push students to engage with their writing at a deeper level, rather than treating composition as a one-pass task.

### **Cross-Domain Patterns**

Across all four domains, the same pattern holds. Effective instruction begins by managing task complexity through analysis and sequencing. Then it reduces extraneous demands by presenting information clearly and cleanly. Finally, it creates conditions for deep processing through structured, varied, and metacognitively rich practice.

What changes across domains is the specific form these actions take; the nature of the task components, the type of visual organization needed, the kind of practice that builds transfer. What stays the same is the underlying logic. Table 3 summarizes the domain-specific applications.

*Table 3: Cross-Domain Application of the Framework*

Domain	Phase 1: Intrinsic Load	Phase 2: Extraneous Load	Phase 3: Germane Load
Mathematics	Sequence from simpler to complex; part-task number fact practice	Integrate problem text, diagrams, and steps; worked examples	Example fading; explain reasoning; varied problem types
Reading	Text levelled to decoding ability; prior knowledge activation	Clear formatting; vocabulary support placed in-text	Summarizing, inferencing, text-to-self connections
Handwriting	Isolated letter practice before words and sentences	Clear, consistent letter models; uncluttered materials	Fluency building; connection to real communication tasks
Writing	Stage-based process: plan, draft, revise separately	Graphic organizers; clear instructions; writing models	Audience awareness; self-evaluation; specific feedback

### TESTABLE PROPOSITIONS

This framework is theoretical, but it is not untestable. It generates several concrete predictions that future research can examine.

First, instruction designed using all three phases should produce better learning outcomes than instruction that addresses only one or two. Managing intrinsic load alone, without reducing extraneous demands or supporting germane processing, should be less effective than a comprehensive approach.

Second, careful task sequencing in Phase 1; moving from simpler to more complex, with part-task training where needed; should improve both early acquisition and retention compared to introducing complex tasks without scaffolding.

Third, reducing extraneous load in Phase 2; through integrated materials, worked examples, and minimal clutter; should reduce subjective difficulty ratings and improve performance, especially for students who report feeling overwhelmed by standard instructional materials.

Fourth, the Phase 3 strategies; example fading, self-explanation, varied practice, and metacognitive prompting; should produce stronger transfer than repetitive, unvaried practice. Students who are asked to explain their reasoning and practice across diverse problem types should be better able to apply their knowledge in new contexts.

Fifth, the effects of the framework should be larger for LD students than for typical learners. Because LD students have reduced functional WM capacity, they stand to gain more from instruction that carefully manages cognitive load. Reducing extraneous demands that a typical learner might simply ignore can make a decisive difference for a student with LD.

Sixth, the cognitive load audit checkpoints should produce measurable benefits compared to a version of the framework without them. Designers who use the audit questions should produce materials with systematically lower extraneous load and better-calibrated task complexity than those who apply the general principles without explicit verification.

Testing these propositions requires studies that measure cognitive load directly; using both subjective rating scales and objective performance indicators; as well as learning outcomes and transfer performance. Comparative designs that pit this framework against single-phase or unstructured approaches will be especially valuable.

## **DISCUSSION**

### **Theoretical Contributions**

The primary contribution of this article is not a new theory of learning. CLT is well established, and the cognitive challenges faced by LD students are well documented. What this framework contributes is a new way of connecting these two bodies of knowledge; a structured, sequential, auditable design process that makes CLT actionable for practitioners working with this population.

The cognitive load audit mechanism is the key novelty. Prior CLT applications have provided design principles and strategy lists, but they have not embedded a verification process within the design workflow. The audit checkpoints do this. They convert CLT from a set of things to think about into a process that can be followed, checked, and reported on. This makes the framework both more practical for designers and more useful for researchers who want to study how CLT-based design decisions affect learning outcomes.

The framework also makes a conceptual contribution by adopting a current, non-additive view of germane load. Rather than treating germane load as a fixed quantity to be increased alongside intrinsic and extraneous loads, the framework treats it as the productive use of remaining capacity. This is consistent with recent theoretical developments (Greenberg & Zheng, 2023) and avoids the logical problem that arises when all three loads are treated as independently additive; a problem that has led some researchers to question whether germane load is a useful concept at all.

### **Implications for Research**

The testable propositions in Section 7 provide a clear agenda for future research. The most pressing need is empirical testing; comparative studies that examine whether instruction designed using this framework produces better outcomes than instruction designed without it, on measures of cognitive load, learning, and transfer.

Beyond basic efficacy testing, research should examine whether the framework works differently across domains, age groups, and disability subtypes. Students with dyslexia, dyscalculia, and dysgraphia may require different emphases within the framework, even if the overall structure remains the same. Research that investigates these nuances will help refine the model and increase its precision.

The audit mechanism itself deserves study. Does using the audit checkpoints actually improve design quality? Do they reduce extraneous load in the resulting materials? Are they usable by novice teachers as well as experienced designers? These questions are practical and answerable.

Finally, research on cognitive load measurement in LD students remains an important priority. Self-report scales and performance-based indicators are both imperfect. More reliable measurement tools would strengthen the entire line of research, not just work on this framework.

### **Implications for Practice**

For teachers and intervention designers, the framework offers something that general CLT guidance does not: a process to follow, not just principles to remember. The phase structure gives practitioners a starting point and a sequence. The audit questions give them a way to check their work. This reduces the cognitive demand of design itself; which is an appropriate goal, given that teachers are also working with limited time and cognitive resources.

The framework can also serve as a professional development tool. It provides a shared vocabulary for discussing instructional design decisions, and it gives coaches and mentors a structure for observing and giving feedback on curriculum development. Teachers who understand the three-load model and the audit logic can begin evaluating their own materials more systematically.

Effective use of the framework requires some familiarity with CLT concepts. Training and support will be needed, particularly for teachers who have not encountered CLT before. This is a realistic constraint that should be addressed in any implementation effort.

### **Relationship to Existing Frameworks**

This framework is designed to work alongside existing approaches, not against them. Explicit instruction, for example, is highly compatible: its emphasis on modelling, guided practice, and gradual release of responsibility maps directly onto the logic of Phase 2 (worked examples) and Phase 3 (example fading, independent practice). The framework provides the cognitive design rationale that explicit instruction implies but does not always articulate.

Similarly, UDL's emphasis on multiple means of representation is consistent with the framework's attention to extraneous load; offering content in multiple formats reduces the likelihood that any one student will be unable to process the material. The framework adds cognitive specificity to UDL's accessibility goals.

4C/ID's whole-task orientation is also compatible: the framework's Phase 1 analysis maps onto 4C/ID's task decomposition, and the framework's audit mechanism provides a quality check that 4C/ID does not include. Together, these frameworks offer complementary lenses on the same challenge.

### **Summary**

This framework offers a practical, theoretically grounded approach to designing instruction for LD students. Its key contributions are a sequential phase structure that operationalizes CLT, an explicit focus on the cognitive profile of this population, and an embedded audit mechanism that makes the design process verifiable. It is a starting point; valuable as a tool for organizing thinking and generating research; but its real worth will be established through empirical testing and iterative refinement.

### **LIMITATIONS AND FUTURE DIRECTIONS**

This article has several important limitations that should be acknowledged.

The framework has not been tested in real classrooms. It rests on established theory and research, but its effects on learning outcomes, cognitive load, and transfer remain to be demonstrated empirically. Until that evidence is available, the framework should be treated as a structured hypothesis, not a validated intervention.

The framework focuses primarily on cognitive load. Learning is shaped by many factors beyond cognition; motivation, affect, prior experience, social context, and the physical environment all matter. These factors are not addressed in the framework, and they may interact with cognitive load in ways that complicate the predictions made here. A fuller understanding of instructional design for LD students will need to integrate these dimensions.

The framework assumes a degree of design expertise. Using it well requires understanding what CLT means, how to analyse task complexity, and how to make nuanced decisions about presentation and practice. Teachers without this background may struggle to apply it effectively without support. Implementation research should examine what training and scaffolding are needed.

The illustrative examples in Section 6 are just that; illustrations. They have not been validated in practice. Different subjects, different age groups, and different cultural contexts may require adaptations that are not yet understood.

Future directions follow naturally from these limitations. Empirical testing is the most urgent priority. Researchers should design studies that compare this framework against alternative approaches on measures of cognitive load, learning outcomes, and knowledge transfer; particularly in samples of LD students. Within-framework studies should also examine whether the audit mechanism contributes independently to design quality.

Researchers should also investigate domain-specific applications more closely. The framework may require different emphases in mathematics versus reading, or for students with different disability profiles. Understanding this variability will increase the framework's practical utility.

Finally, the framework should be developed into practical tools; structured design templates, audit checklists, worked examples of the design process; that make it accessible to teachers who are not researchers. This kind of translation work is often undervalued, but it is essential if theory is to influence practice.

## **CONCLUSION**

LD students face a learning environment that is routinely not designed with their cognitive needs in mind. CLT has provided tools for thinking about this problem for decades, but it has not been organized into a practical design process. This framework is an attempt to close that gap.

By translating CLT into three sequential, auditable phases; managing intrinsic load, reducing extraneous load, and fostering germane load; the framework gives researchers and practitioners a structured way to design instruction that accounts for the specific cognitive challenges these students face. The embedded audit mechanism is the central innovation: it turns CLT principles into verifiable design decisions, not just conceptual guidelines.

The framework is a beginning, not an endpoint. Its value will be determined by the research it generates, the practice it improves, and the learning outcomes it ultimately supports. The goal is instruction that works; that meets LD students where they are and helps them build the knowledge and skills they need. That is the standard against which this framework, and any revision of it, should be judged.

## DECLARATIONS

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- Ethical Considerations: This study is conceptual in nature and does not involve human participants, data collection, or ethical approval requirements.

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