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COGNITIVE LOAD AND SCAFFOLDING IN URDU LITERACY INSTRUCTION: A SCRIPT-SENSITIVE THEORETICAL FRAMEWORK

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Abstract

Learning to read and write in Urdu involves script-related demands that can burden working memory, especially for novice learners. How much load these demands create depends on the learner's prior knowledge, the task, and the instructional context. The cursive, ligature-based Nastaliq orthography right-to-left directionality, the absence of short vowel markers, morphological complexity, and the gap between spoken and formal written Urdu all place demands on working memory that generic literacy instruction is not designed to address. Cognitive Load Theory (CLT) offers a useful theoretical lens for understanding these demands. Yet CLT has been developed almost entirely around language-neutral or alphabetic-language contexts. It does not offer a principled account of how script-specific properties generate cognitive load or how instructional scaffolding should respond to those properties. This article addresses that gap. It introduces the concept of Script Complexity Load (SCL), a theoretically derived, Urdu-specific construct that proposes five sub-dimensions of script-linked load, drawn from the Urdu writing system and the language demands it makes visible in print: orthographic complexity, directional load, inferential load, morphological load, and register load. The core of each sub-dimension is treated as intrinsic load, while directional and register load also have a design-induced, extraneous component. Building on this construct, the article presents a three-phase scaffolded instructional design framework that translates SCL into actionable design decisions. Each phase includes a structured audit mechanism that prompts designers to verify load conditions before progressing. The framework bridges CLT, scaffolding theory, and Urdu linguistics into a proposed design model. It is intended for researchers, curriculum designers, and educators working in Urdu literacy instruction, and it generates testable propositions for future

empirical work. The article is conceptual in nature. The framework is theory-derived and requires empirical testing before it can be treated as a validated model.

Keywords
cognitive load theory; Nastaliq; scaffolding; script complexity; Urdu literacy; working memory

1. INTRODUCTION

Literacy is not a single skill. It is a cluster of abilities that depend on each other. These abilities include recognizing letters, decoding words, understanding morphology, and holding meaning in mind long enough to construct a sentence, a paragraph, or a text (Ne'eman & Shaul, 2023). All of this happens in working memory, which is limited in capacity and easily overwhelmed.

This is why cognitive load matters in literacy instruction. When the demands of reading or writing exceed what working memory can handle, learning breaks down. A learner who is struggling to recognize letter forms has no capacity left for understanding words (Acha et al., 2023). A learner who is unsure whether to read left-to-right or right-to-left loses cognitive resources to spatial confusion before a single word is decoded. These problems are not purely abstract, and teachers often observe them in classrooms, although their severity differs from learner to learner.

Cognitive Load Theory (CLT) has given educators and researchers a powerful set of tools for thinking about these problems (Sweller, 2011; Sweller, 2023). CLT categorizes cognitive demands into three groups: intrinsic cognitive load (ICL) (from the content itself), extraneous cognitive load (ECL) (from how content is presented), and germane cognitive load (GCL) (the productive effort that builds understanding). CLT has shaped instructional design across many domains. Its influence on literacy instruction has been meaningful. But the application of CLT has been mostly limited to alphabetic languages, particularly English.

Urdu presents a distinct set of demands. It is written in the Nastaliq script, a cursive, ligature-based orthographic system with right-to-left directionality, no obligatory short vowel markers, and substantial morphological complexity (Naz et al., 2017). Formal written Urdu also differs significantly from everyday spoken Urdu, creating a register gap that learners must bridge without explicit instruction (Ambreen & To, 2024). These features are not incidental. These features are structural properties of the writing system and the language, and they are likely to create specific cognitive demands that generic CLT-based frameworks do not address. How strongly they affect a given learner depends on other factors as well, including prior literacy experience, oral language proficiency, the quality of instruction, and the print environment (McBride et al., 2022).

Scaffolding theory offers a complementary perspective. Rooted in Vygotsky's concept of the zone of proximal development (ZPD), scaffolding refers to the temporary, adjustable support that enables learners to accomplish tasks they could not manage independently (Wood et al., 1976; Vygotsky, 1978). In literacy instruction, scaffolding has most often been operationalized through strategies like modeling, guided practice, and gradual release of responsibility. But scaffolding theory has not been systematically integrated with CLT, and neither has been applied to the specific script-level demands of Urdu.

This article attempts to close these gaps. It makes three contributions. First, it introduces the construct of Script Complexity Load (SCL), a theoretically derived account of how the structural properties of Urdu may generate distinct sub-dimensions of cognitive load. Second, it integrates SCL into a three-phase instructional design framework that combines CLT and scaffolding theory into a proposed design model. Third, it embeds a structured audit mechanism within each phase, enabling designers to verify that load conditions have been addressed before advancing. This audit mechanism, adapted from quality assurance thinking in instructional systems design, is intended to turn theoretical principles into explicit, checkable design decisions.

The framework is intended as a theoretical model and a principled foundation for designing and studying Urdu literacy instruction rather than a validated intervention. Its propositions require empirical testing, and the article concludes by outlining a research agenda to support that work. Throughout the article, statements about the framework's effects are presented as theoretically derived propositions, not as established findings.

2. CONCEPTUAL APPROACH

2.1 Nature of the Approach

This article uses a conceptual synthesis methodology. More precisely, it is a theoretical synthesis, not a systematic or scoping review, because its aim is to develop a construct and a design logic and not to summarize all available studies. It does not report new empirical data. Instead, it draws on three bodies of established knowledge, including CLT, scaffolding theory, and Urdu linguistics and literacy research. It integrates them into a proposed theoretical framework. This approach is appropriate when substantial knowledge exists across separate domains that have not been systematically connected (Grames et al., 2022). CLT and Urdu literacy research are both well-developed fields; what is missing is the theoretical bridge between them. Sources were selected purposively for their relevance to the working memory demands of reading and writing in Urdu, with priority given to peer-reviewed and recent work. No systematic search protocol was applied, so the selection should not be read as exhaustive.

2.2 Sources of Integration

The framework draws from three primary sources. The first is CLT, including its three-load model and the instructional principles it has generated (Sweller & Chandler, 1991; Paas et al., 2003; Sweller, 2020). The second is scaffolding theory, specifically the ZPD-based account of supported learning and the conditions under which scaffolding should be provided and withdrawn (Vygotsky, 1978; Wood et al., 1976; van de Pol et al., 2010). The third is research on Urdu script, orthography, and literacy development, including psycholinguistic studies of Urdu reading and pedagogical analyses of Urdu literacy instruction (Rehman, 2011).

2.3 *The Central Theoretical Move*

The central theoretical move in this article is the introduction of Script Complexity Load (SCL). This construct arises from a straightforward observation: the cognitive demands of learning to read and write in Urdu are not fully captured by existing CLT categories. ICL refers to the complexity of the content or task. But in Urdu literacy, a substantial portion of that complexity may originate not in the ideas being communicated but in the properties of the script used to communicate them. SCL names this portion explicitly and disaggregates it into theoretically distinct sub-dimensions. This disaggregation is what makes scaffolding prescriptions possible because different sub-dimensions of SCL require different instructional responses. SCL is not proposed as a fourth type of cognitive load. It is an analytic lens for tracing particular sources of intrinsic load, and some design-induced extraneous load, to the writing system. As CLT holds, whether a given feature actually imposes load depends on learner expertise, element interactivity, and task demands, so script features are treated here as likely, not automatic, sources of load.

2.4 *Scope and Intended Use*

The framework is designed primarily for researchers and instructional designers working in Urdu literacy contexts, whether in Pakistan, diaspora communities, or Urdu-medium educational settings globally. It is also relevant for curriculum developers and teacher educators. The framework is not a teaching script or a lesson plan. It is a design logic for thinking through instructional decisions that is principled, systematic, and responsive to the specific cognitive demands of the Urdu script.

2.5 *Limitations of the Approach*

As a conceptual model, the framework has not been empirically tested (Wang et al., 2023). Its claims about SCL sub-dimensions and their instructional implications are theoretically derived, not empirically validated. Alternative interpretations of the evidence are possible, and the framework does not account for the full range of factors that shape Urdu literacy

development, e.g., motivation, sociolinguistic attitudes toward Urdu, access to print environments, and the influence of prior literacy in other languages. Further limitations concern construct validity, the role of learner expertise, the absence of established measures of SCL, and the difficulty of separating script demands from wider linguistic demands (see Limitations and Future Directions). These limitations define the boundaries of the framework's claims, not its irrelevance.

3. THEORETICAL FOUNDATIONS

3.1 Cognitive Load Theory (CLT)

CLT was originally proposed by Sweller (1988). It begins with the architecture of human cognition. Working memory is a system we use to hold and manipulate information but is limited (Chandler & Sweller, 1991). It can hold only a few pieces of information at once, and those pieces are lost quickly unless they are actively maintained or transferred to long-term memory (Baddeley, 2020; Sweller, 2011). When instruction places too many demands on working memory simultaneously, the system becomes overloaded and learning breaks down (Castro-Alonso et al. 2021).

CLT categorizes these demands into three types (Chang et al., 2021). ICL comes from the content itself, how complex the material is, and how many elements must be understood in relation to each other (Endres et al., 2023). ECL comes from how the content is presented; poorly designed materials, split-attention layouts, redundant information, and visual clutter all add to ECL without contributing to learning (Çakıroğlu & Aksoy, 2017). GCL reflects the productive cognitive effort that builds understanding, connections, and schemas that can be retrieved and applied later. Consistent with current theoretical developments, this framework treats GCL not as a fixed additive quantity but as the productive use of whatever working memory capacity remains once ICL and ECL have been managed (Greenberg & Zheng, 2023; Sweller, 2010).

These distinctions have generated a rich set of instructional principles: worked examples, sequential task design, split-attention reduction, modality effects, the expertise reversal effect, and others (Fraser et al., 2015; Kirschner et al., 2018). But these principles have been developed almost exclusively in the context of alphabetic or logographic languages, primarily English, German, and Chinese. Their application to Urdu requires theoretical work that has not yet been done.

3.2 Scaffolding Theory

Scaffolding theory originates in Vygotsky's (1978) concept of the zone of proximal development. ZPD refers to the space between what a learner can do independently and what they can do with skilled support (Bozhovich, 2009). Instruction that operates within ZPD challenges learners without overwhelming them (Margolis, 2020). Scaffolding is the

mechanism through which this is achieved: temporary, adjustable support that enables learners to accomplish tasks they cannot yet manage alone and that is progressively withdrawn as competence develops (Wood et al., 1976).

The ZPD is especially relevant to literacy acquisition because literacy is built cumulatively. Early skills such as letter recognition and letter-sound mapping must become reasonably automatic before learners can devote working memory to word meaning and text comprehension (Lambright, 2024). At any point, the skills that sit just beyond a learner's independent reach define the zone in which guided support is most useful, for example when an adult models a ligature, points out the reading direction, or reads a word aloud before the learner attempts it. Common scaffolding practices in literacy classrooms, such as modeling, guided practice, and gradual release of responsibility, match support to the learner's next step in this sequence (Taylor et al., 2026). In Urdu, many of these early steps are script-level skills, which is why scaffolding decisions need to be tied to specific script demands.

The relationship between scaffolding and cognitive load is intuitive but has rarely been made explicit (van Nooijen et al., 2024). Scaffolding reduces cognitive load by taking over the parts of a task that exceed the learner's current capacity. Thus, it allows working memory to focus on the parts that are within reach. As the learner's knowledge and skill grow and more operations become automatic and less demanding of working memory, the scaffold is faded, and the learner takes over progressively more of the task. This is consistent with the logic of CLT's expertise reversal effect: what supports novices can impede experts, because the support itself consumes working memory capacity that experts no longer need to offload (Kalyuga et al., 2003). In this framework, scaffolding acts mainly on ICL and ECL. It reduces intrinsic load by taking over parts of the task, and it reduces extraneous load by removing unnecessary processing. Its link to GCL is indirect. By freeing capacity, scaffolding allows learners to invest effort in schema construction, so scaffolds that are withdrawn too early or kept too long can both limit the capacity available for germane processing.

For Urdu literacy, this relationship has direct implications. Scaffolding decisions in Urdu cannot be made generically; they must be calibrated to the specific cognitive demands created by the script. Different sub-dimensions of script complexity require different scaffolding strategies and different fading trajectories. This is the core design insight that the SCL construct is intended to support.

3.3 *Urdu Script: Structural Properties and Cognitive Demands*

Urdu is written in a modified form of the Perso-Arabic script, rendered in the Nastaliq calligraphic style (Murtaza & Khanum, 2023). Understanding what makes Urdu literacy cognitively demanding requires understanding the structural properties of this script, not just describing them but theorizing why each property creates a specific type of cognitive load.

Nastaliq orthography is ligature-based. Individual letters change form depending on their position within a word, i.e., initial, medial, final, or isolated. A learner must simultaneously recognize the abstract letter identity and its positional variant while also parsing the ligature connections between adjacent letters (Wali & Hussain, 2007). This places concurrent demands on visual pattern recognition and working memory that may be greater than those imposed by non-cursive alphabetic scripts, although this comparison has not been directly tested.

Urdu is written right-to-left. For learners whose prior experience with print is left-to-right, this directional conflict may add to cognitive load, whereas learners who already read other right-to-left scripts, such as Arabic or Persian, may experience little or none. For learners who do experience the conflict, attention must be directed against a default spatial orientation, consuming working memory resources that would otherwise be available for decoding (Khan et al., 2025).

Short vowels in Urdu are represented by diacritical marks (erabs) that are typically omitted in standard written texts. Skilled readers infer vowel sounds from context, morphological knowledge, and familiarity with lexical patterns (Ambreen & To, 2025; Niazi et al., 2023). Novice readers lack this knowledge base and must therefore hold multiple possible vowel interpretations in working memory simultaneously while attempting to decode (Rehman, 2011). It is a form of sustained inferential processing that adds to ICL.

Urdu morphology is root-based and productive. Many words are derived from shared roots through systematic patterns of affixation and internal change (Safdar & Mangrio, 2021). Reading and writing in Urdu require learners to track these morphological relationships, recognizing not just individual words but the morphemic components within them (Batool & Saleem, 2023). This adds a layer of simultaneous processing that compounds the demands already created by the script (Benmamoun et al., 2013).

Finally, formal written Urdu differs from the informal spoken Urdu that most learners already know (Akhtar et al., 2025). Vocabulary, syntax, and register all shift between the spoken and written forms (Aftab et al., 2023). This means that literacy instruction in Urdu cannot simply build on existing oral language knowledge; it must also bridge the register gap, which creates an additional source of ICL that is absent in languages where the spoken and written forms are more closely aligned (Rahman, 2011).

3.4 Introducing Script Complexity Load (SCL)

The five structural properties described above are not simply aspects of Urdu that make it difficult to learn. They are proposed here as theoretically distinct sources of cognitive load that can be named, categorized, and addressed through targeted instructional design. This is the insight behind the SCL construct.

SCL is defined as the working memory demand generated specifically by the structural properties of the Urdu script, as distinct from the conceptual or communicative demands of

the content being read or written. Its core is a category of ICL, but unlike generic ICL, but unlike generic ICL, which reflects the complexity of ideas, SCL reflects the complexity of the orthographic, directional, inferential, morphological, and register demands embedded in the written system.

SCL is organized into five sub-dimensions, each corresponding to one of the structural properties described above: orthographic complexity (Nastaliq letter forms and ligatures), directional load (right-to-left processing), inferential load (absent erabs), morphological load (root-based derivational complexity), and register load (spoken-written register gap). Table 1 summarizes these sub-dimensions, their nature, their load type, and their relationship to existing CLT categories.

SCL is not proposed as a fourth type of cognitive load, and it does not replace ICL or ECL. It is an analytic lens that helps designers trace particular sources of load to the writing system. In CLT terms, the core of each sub-dimension is intrinsic, because it reflects element interactivity that a novice must process while learning to read and write Urdu, such as holding a letter's shape, position, and ligature links in mind at once. Because intrinsic load depends on expertise, this core is expected to shrink as skills become automatic, and it may differ across learners with different prior experience of Perso-Arabic scripts. Directional and register load also have a design-induced component. Mixed-direction layouts, or formal texts presented without any bridge to spoken forms, add demands that do not belong to the script itself and can be removed by better design. That component is extraneous. Phase 1 therefore addresses the intrinsic core, and Phase 2 addresses the design-induced component.

Morphological and register load deserve a further note, because they are partly linguistic and not purely orthographic. They are included in SCL because, in Urdu, the writing system shapes how learners meet them. Unmarked short vowels may obscure the root-and-pattern structure of words, and the formal written register is the form that learners meet mainly in print (Ambreen & To, 2025). Even so, the boundary between script demands and wider language demands is not sharp. It is treated here as a conceptual limitation of the framework and is returned to in the limitations section.

Table 1 – Script-Specific Cognitive Load Sources in Urdu

Script Feature	Nature of Load	Load Type	SCL Sub-Dimension
Nastaliq orthography	Ligature-based letter forms require simultaneous recognition of shape and position.	ICL	Orthographic complexity

Right-to-left directionality	Conflicts with default left-to-right spatial processing; increases directional confusion	ICL (core) + ECL (design-induced)	Directional load
Absent short vowels (erabs)	Readers must infer vowel sounds from context and morphological knowledge.	ICL	Inferential load
Morphological complexity	Root-based derivations require tracking multiple meaning-bearing units simultaneously.	ICL	Morphological load
Spoken-written register gap	Formal written Urdu differs substantially from everyday spoken forms.	ICL (core) + ECL (design-induced)	Register load

Source: Author

The value of this disaggregation is practical as well as theoretical. Each sub-dimension of SCL is expected to call for a different scaffolding response. A designer who knows that a learner is struggling with inferential load (absent errors) should respond differently than one who knows the learner is struggling with directional load (right-to-left processing). Generic CLT guidance does not offer this level of precision. SCL is intended to.

4. POSITIONING WITHIN EXISTING FRAMEWORKS

Several theoretical frameworks are relevant to Urdu literacy instruction. Each offers something useful, but none provides the combination of cognitive load specificity and script sensitivity that the present framework aims to deliver.

CLT in its general form provides the foundational theoretical architecture. Its three-load model and instructional principles are well supported empirically and have broad applicability. But CLT treats the language medium as essentially transparent: a neutral vehicle for content. It does not theorize how the properties of a specific script generate cognitive load, and it does not offer design guidance calibrated to orthographic, directional, or morphological complexity. The SCL construct is intended to extend CLT into this territory.

Scaffolding theory provides a developmental rationale for adjustable instructional support. It is sensitive to learner differences and responsive to growth over time. But scaffolding theory does not come with a cognitive load mechanism. It tells us that support should match the learner's current capacity, but it does not tell us how to measure or analyze that capacity in terms of specific script demands. Integrating scaffolding theory with SCL provides that mechanism.

The Simple View of Reading (SVR) offers a parsimonious model of reading as the product of decoding and linguistic comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). It has been influential in literacy research and instruction. But SVR is language- and script-neutral. It treats decoding as a unitary process, without accounting for the script-specific cognitive demands that make decoding in Urdu qualitatively different from decoding in English. The present framework seeks to extend SVR by proposing what decoding in Urdu may involve at the cognitive level.

Urdu literacy research has generated valuable descriptive accounts of how children and adults learn to read and write in Urdu (Rehman, 2011). These studies document the challenges learners face and identify the features of Urdu that make literacy acquisition difficult. But they have rarely theorized these challenges through a cognitive load lens, and they have not produced a design framework that translates their findings into instructional prescriptions. The present framework attempts to do this.

ZPD-based scaffolding research in second language acquisition has explored how support can be calibrated to learner need in language learning contexts (Lantolf & Thorne, 2006; van de Pol et al., 2010). But this work has focused primarily on oral language development and grammatical acquisition, not on script-level literacy challenges. The present framework addresses a gap that L2 scaffolding research has not engaged with directly. Table 2 summarizes this positioning.

Table 2 - Positioning of the Present Framework

Framework	Primary Focus	Strength	Limitation	Contribution of Present Framework
CLT (general)	Cognitive load in learning	Strong theoretical base	Language-neutral; no script-specific theory	Adds script-specific load construct (SCL) for Urdu
Scaffolding theory (ZPD)	Supported learning progression	Developmental sensitivity	No cognitive load mechanism	Provides cognitive load rationale for scaffolding decisions
Simple View of Reading	Reading = decoding × comprehension	Parsimonious model	Language- and script-neutral	Extends SVR by specifying script-level cognitive demands in Urdu
Urdu literacy research	Descriptive accounts of Urdu reading	Language-specific insight	Rarely theorized through a cognitive load lens	Integrates Urdu-specific findings into a designable framework
ZPD-based L2 scaffolding	Second language acquisition support	Interaction-centered	Not applicable to script-level challenges	Addresses the script as a distinct cognitive domain requiring targeted scaffolding.

Source: Author

5. A SCRIPT-SENSITIVE FRAMEWORK FOR URDU LITERACY INSTRUCTION

5.1 *Overview*

The framework organizes instructional design for Urdu literacy into three sequential phases. Phase 1 addresses Script Complexity Load: the identification and sequencing of script-specific cognitive demands. Phase 2 addresses ECL: the reduction of unnecessary cognitive demands from material design. Phase 3 addresses GCL: the creation of conditions for deep processing and schema formation.

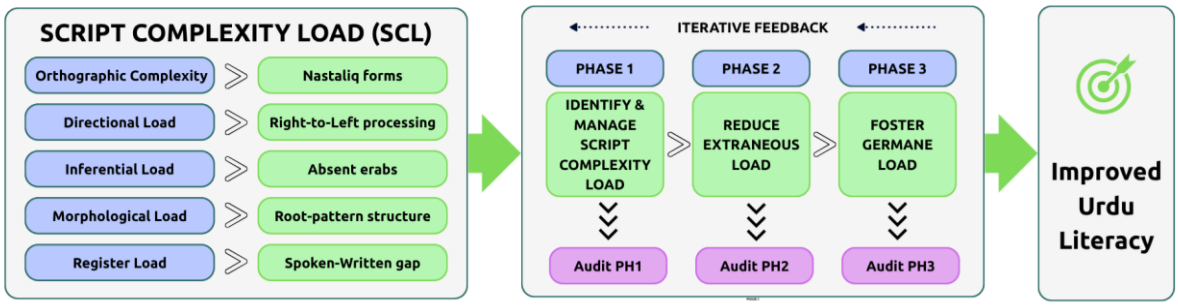
Within each phase, designers make specific decisions about task structure, material design, or learning activity. At the end of each phase, a structured SCL audit prompts the designer to verify that the phase's objectives have been met before advancing. This audit mechanism is what distinguishes the framework from general CLT guidance: it is intended to turn principles into explicit checkpoints, which may make the design process more systematic and transparent.

In this framework, the SCL audit is a structured self-check completed by the designer or teacher at the end of each phase. Each audit question is paired with an indicator that can be recorded as evidence, such as a learner error analysis, a short accuracy check on letter forms or reading direction, a materials review, or a brief teacher observation record. A phase is treated as complete when the evidence for each question meets a criterion that the designer sets in advance for the target learners. If it does not, the designer returns to the relevant phase and revises. The indicators and criteria suggested in this article are illustrative. Because SCL has not been validated, they should be read as a starting structure for local piloting and not as standardized measures (Boateng et al., 2018). The audit is called the SCL audit in all three phases because each phase uses it to check how well the SCL profile from Phase 1 has been respected.

The three phases are presented sequentially, but the framework is iterative. Evidence of difficulty during Phase 3 activities may indicate unresolved issues in Phase 1 or 2, and designers should return to earlier phases as needed.

Some strategies appear in more than one phase because they serve a different purpose in each. For example, directional cues are chosen in Phase 1 as a scaffold for directional load and are built into the layout of materials in Phase 2 so that they do not clash with other cues. The phases are therefore distinguished by the question each one asks, namely what demands are present, which demands come from the design, and how support should be withdrawn, and not by the strategies they use.

Figure 1 – The Script-Sensitive CLT-Scaffolding Framework for Urdu Literacy



Source: Author

5.2 *Core Assumptions*

The framework rests on four assumptions. First, the structural properties of Urdu are likely to generate categorizable cognitive demands that can be identified in advance and addressed through design. Second, scaffolding decisions must be calibrated to specific SCL sub-dimensions, not to generic difficulty. Third, the three phases of the framework address different types of cognitive load and are best worked through in order when a new design is being developed, although learners' needs may require moving between phases. ECL is difficult to reduce meaningfully before script-specific demands have been identified, and GCL is unlikely to be fostered effectively before the first two have been addressed. The order follows CLT's logic. Intrinsic demands set the baseline load that materials and tasks must respect, extraneous load is the part of that load which design can remove once the baseline is known, and germane processing draws on whatever capacity remains. Fourth, the framework is iterative: design decisions made in one phase may need to be revised in light of what is learned in subsequent phases or through piloting.

5.3 *Phase 1: Identifying and Managing Script Complexity Load*

The first phase is the one that distinguishes this framework most clearly from general CLT applications. Before any other design decisions can be made, the designer must understand what specific script-level demands the learner will face and in what order those demands should be introduced.

This phase begins with an SCL profile. The designer works through each of the five sub-dimensions—orthographic complexity, directional load, inferential load, morphological load, and register load—and assesses how demanding each sub-dimension is likely to be for the target learner population. This assessment draws on knowledge of the learners' prior literacy experiences, their familiarity with the Perso-Arabic script, their morphological awareness in Urdu, and their exposure to formal written Urdu. In practice, the profile can rate each sub-dimension as low, moderate, or high for the target group, using simple evidence such as a

short diagnostic task, a review of learners' reading errors, and information about prior literacy in other languages or scripts. Because prior experience changes the load, the same sub-dimension may be rated differently for learners who already read Arabic or Persian than for learners who do not.

Based on this profile, the designer sequences the introduction of script-level demands from lower to higher complexity. Orthographic and directional demands are typically addressed first, since they affect the most fundamental operations, e.g., letter recognition and reading direction, without which other decoding processes cannot proceed. Inferential and morphological demands are introduced progressively as the learner develops foundational script knowledge. Register demands are typically addressed later, once learners have established basic fluency with the script itself.

Figure 2 summarizes this sequencing. It shows the proposed prominence of each sub-dimension across early, middle, and later stages of Urdu literacy development. Orthographic and directional demands are expected to be most prominent at the start. Inferential and morphological demands are expected to become more prominent as learners begin to process unmarked text and morphologically complex words, and register demands are expected to be most salient as learners move toward formal written Urdu. The figure is conceptual. It reflects the framework's proposed developmental ordering and is not a measure of effect size or predictive strength. Whether the ordering holds, and how it varies with learners' prior experience of the script, is an empirical question.

Figure 2 – Proposed Conceptual Prominence of SCL Sub-Dimensions Across Urdu Literacy Development

	Stage of Urdu literacy development			
	Early	**Middle**	**Later**	**Proposed tier**
Orthographic complexity	Highest	Moderate	Lower	*Foundational*
Directional load	Highest	Moderate	Lower	*Foundational*
Inferential load	Lower	Highest	Moderate	*Developing*
Morphological load	Lower	Highest	Moderate	*Developing*
Register load	Lower	Moderate	Highest	*Later*

Conceptual, theory-based ordering of prominence. Not an empirical measure of effect size or strength of association.

Source: Author

Scaffolding within this phase is script-specific. For orthographic complexity, this means beginning with isolated letter forms before introducing positional variants and ligatures and using materials that systematically expose learners to the full set of Nastaliq forms in a controlled sequence. For directional load, it means explicit directional cuing, e.g., consistent right-to-left layout, spatial anchor prompts, and activities that build directional automaticity. For inferential load, it means beginning with erabs-marked texts and progressively removing diacritics as morphological knowledge develops. For morphological load, it means explicit root-and-pattern instruction that builds morphological awareness before expecting learners to handle complex derived forms independently. For register load, it means using bridge texts that draw on familiar spoken vocabulary before introducing formal written Urdu.

SCL Audit for Phase 1: Before moving to Phase 2, the designer should verify the following: Have all five SCL sub-dimensions been assessed for the target population? Is the introduction sequence ordered from lower to higher complexity? Is there a clear scaffolding strategy for each sub-dimension? Are the scaffolds specific to each sub-dimension's demands, not generic? If any of these questions cannot be answered affirmatively, Phase 1 should be revisited. Illustrative indicators include a completed SCL profile with a low, moderate, or high rating for each sub-dimension, supported by a short diagnostic (for example, accuracy in identifying positional letter forms, tracking reading direction, and reading erabs-marked and unmarked words) scored against a criterion that the designer sets in advance. These indicators are untested.

5.4 *Phase 2: Reducing ECL in Urdu Materials*

Once the script-specific demands have been identified and sequenced, the designer turns to the materials themselves. ECL in Urdu literacy materials takes forms that are specific to the script and do not appear in alphabetic language materials. These must be understood and minimized before learners can direct their cognitive resources toward actual learning.

Typography is a primary source of ECL in Urdu. Nastaliq is a complex calligraphic style. Using complex calligraphy styles creates unnecessary variability in letter forms.

Layout is another important source. Right-to-left text placement, paragraph direction, and page orientation must all be consistent and unambiguous. Materials that mix left-to-right and right-to-left elements, as sometimes happens in bilingual or digitally formatted materials, create directional confusion that falls squarely in the ECL category.

Vocabulary support should be embedded, not separated. In many Urdu literacy materials, unfamiliar words are explained in a glossary at the end of the text or in a separate panel on the opposite page. This forces learners to divide their attention between the text and the support, creating split-attention effects that consume working memory. Integrating vocabulary support through in-text glosses, illustrations adjacent to the relevant word, or margin notes positioned alongside the relevant line eliminates this problem.

Worked examples are valuable in this phase. For Urdu reading, this might mean fully annotated texts in which letter forms are explicitly labeled, directional arrows indicate reading direction, and erabs are provided. For writing, it might mean step-by-step demonstrations of letter formation in Nastaliq. These examples reduce the inferential demands placed on novice learners and allow working memory to focus on the target skill.

SCL Audit for Phase 2: Before moving to Phase 3, the designer should verify: Is a single, consistent Nastaliq font used throughout? Is the layout consistently right-to-left, with no conflicting directional cues? Is vocabulary support embedded adjacent to the relevant text, not separated? Have worked examples been provided for the most demanding script operations? Are materials free of visual clutter, e.g., decorative elements, competing graphics, or dense text blocks that would consume working memory without contributing to learning? If not, revise before proceeding. Illustrative indicators include a materials review in which two reviewers rate each item as met or not met, with their agreement noted, and a brief learner rating of mental effort on revised materials using an adapted rating scale (Barth et al., 2017). These indicators are untested.

5.5 *Phase 3: Fostering GCL in Urdu Literacy*

The third phase creates the conditions for deep, lasting learning. It is likely to be effective only once Phases 1 and 2 have been at least partly addressed, once the script-specific demands have been scaffolded and the materials have been cleaned of ECL. At that point, learners have sufficient cognitive capacity to engage in the kind of active processing that builds transferable understanding.

Scaffold fading is the central mechanism of this phase. Supports introduced in Phase 1 (erabs marking, directional cues, and morphological glosses) are progressively withdrawn as the learner demonstrates competence. This withdrawal is not arbitrary; it is guided by evidence of the learner's growing independence on specific SCL sub-dimensions. A learner who no longer needs directional cuing may still need erabs support. Fading should be sub-dimension-specific, not global. In this way, scaffold fading is where scaffolding and GCL meet: as supports are withdrawn, capacity freed earlier is gradually redirected to schema-building tasks such as morphological sorting and self-explanation.

Morphological awareness activities form a crucial component of this phase. Tasks that ask learners to identify roots in unfamiliar words, generate derived forms from known roots, or sort words by morphological family push learners to engage actively with the structural logic of Urdu. This kind of engagement builds the morphological knowledge that, once automatized, is expected to reduce the inferential and morphological load of future reading.

Self-explanation is particularly valuable in the Urdu context. When learners articulate why a word is read a certain way, why a particular vowel is implied, and why a root is identified where it is. They deepen their processing of the script's underlying logic. This kind of

metacognitive engagement is harder to achieve in Urdu than in languages with transparent orthographies, because the implicit rules of the script are not obvious. Making them explicit through self-explanation tasks may speed their internalization.

Varied text types matter too. Learners who have only encountered instructional texts may struggle when faced with narrative prose, poetry, or functional texts (forms, signs, notices). Exposing learners to varied text types (progressively and with appropriate support) builds the flexible reading skill that transfers beyond the classroom.

SCL Audit for Phase 3: After designing learning activities, the designer should verify the following: Is scaffold fading sub-dimension-specific, not global? Do activities require active engagement with script structure and morphology, not just passive reading? Is there a clear progression from supported to independent practice? Are varied text types included? Do activities prompt learners to articulate and reflect on the rules they are applying? Revise as needed before finalizing. Illustrative indicators include the proportion of tasks that learners complete independently, the number of scaffolds withdrawn for each sub-dimension, and accuracy on unmarked text and morphologically complex words against a preset criterion. These indicators are untested.

5.6 *The Iterative Nature of the Framework*

The three phases are sequential in logic but iterative in practice. During Phase 3, if learners struggle with activities that should be within their reach, the designer should ask whether Phases 1 or 2 have been fully addressed. Perhaps the SCL profile in Phase 1 underestimated the demands of morphological complexity. Perhaps a typographic inconsistency in Phase 2 is still creating ECL. The audit questions are designed to surface these problems, but they may not catch everything on the first pass. Iteration can take two forms. Design-level iteration occurs when audit evidence shows that a phase has not been met and the designer revisits it before moving on. Learner-level iteration occurs when a learner's performance shows that one sub-dimension needs more support, in which case the teacher returns to the Phase 1 or Phase 2 supports for that sub-dimension without restarting the whole sequence. Phases can also overlap for the same learner, with one sub-dimension at the fading stage while another is still being scaffolded.

The framework should be thought of as a design cycle. Initial implementation generates evidence through learner performance, engagement, and difficulty patterns that feeds back into earlier design decisions. This iterative quality is not a weakness; it is a feature. It means the framework supports continuous improvement, not just one-time design. To keep the status of claims clear, the content of the framework can be read at three levels. Its descriptions of Urdu script properties draw on existing linguistic and psycholinguistic literature. Its links between those properties and cognitive load are theoretical inferences

from CLT. Its scaffolding prescriptions, audit indicators, and phase sequence are design proposals and hypotheses that have not been tested.

Table 3 - Summary of the Script-Sensitive Framework for Urdu Literacy Instruction

Phase	Focus	Primary Goal	Key Design Actions	SCL Audit Question
1	Script Complexity Load	Identify and sequence script-specific demands	SCL profiling, sub-dimension ranking, progressive script exposure, and erabs scaffolding	Have all five SCL sub-dimensions been assessed? Is exposure sequenced from lowest to highest demand?
2	ECL	Eliminate unnecessary cognitive demands from material design	Consistent Nastaliq typography; right-to-left layout cues; redundancy removal; integrated vocabulary support	Are materials free of conflicting spatial and typographic cues? Is vocabulary support embedded, not separate?
3	GCL	Support schema formation for Urdu script and morphology.	Progressive scaffold fading; morphological awareness tasks; self-explanation; varied text types	Do activities require active engagement with the script and meaning? Is there a progression toward independent reading?

Source: Author

6. SCAFFOLDING CALIBRATION

One of the practical contributions of the SCL construct is that it makes scaffolding calibration explicit. Rather than deciding on scaffolding supports in general terms, e.g., 'provide more support for struggling learners,' designers can ask a more precise question: Which sub-dimension of SCL is generating difficulty, and what specific scaffold addresses that sub-dimension?

Table 4 maps each SCL sub-dimension to the scaffolding strategies that target it, with brief explanations of the cognitive mechanism through which each strategy works.

Table 4 - SCL Sub-Dimensions and Targeted Scaffolding Strategies

SCL Sub-Dimension	Primary Load Type	Scaffolding Strategy	Mechanism
Orthographic complexity	ICL	Letter-in-isolation practice before ligature recognition; progressive form exposure	Reduces simultaneous processing demands on letter-position combinations
Directional load	ICL (core) + ECL (design-induced)	Explicit directional cuing; spatial anchoring prompts; consistent right-to-left layout	Builds directional automaticity; removes conflicting spatial cues

Inferential load	ICL	Erabs-marked texts initially; progressive removal as morphological knowledge develops	Reduces inferential demands until the reader has a sufficient knowledge base.
Morphological load	ICL	Root-and-pattern instruction; explicit morpheme identification tasks	Builds morphological awareness, reducing working memory demand during reading
Register load	ICL (core) + ECL (design-induced)	Bridge texts using familiar spoken vocabulary before formal register: explicit register comparison.	Reduces the gap between what the learner knows and what the text demands.

Source: Author

This mapping is not exhaustive. Teachers and designers will encounter learners who need scaffolding combinations that are not listed here, and the specific form of any scaffold will vary with context, age, and prior knowledge. But the mapping provides a principled starting point, i.e., one that is grounded in the cognitive structure of the task, not in general notions of 'difficulty' or 'support.'

The fading of each scaffold should also be calibrated to the sub-dimension it addresses. Directional scaffolds (arrows, layout cues) should be faded as the learner demonstrates consistent right-to-left tracking without prompting. Erabs should be removed progressively, beginning with high-frequency words where morphological patterns are well established. Morphological glosses should be withdrawn as the learner's root-recognition accuracy improves. Register scaffolds (bridge texts) should be faded as the learner demonstrates understanding of formal written vocabulary in context.

7. TESTABLE PROPOSITIONS

The framework generates a set of testable predictions. These propositions are the empirical face of the theoretical model, the claims that future research should investigate.

To make these propositions testable, each sub-dimension needs a working operational definition. The following are proposed as starting points. Orthographic complexity could be indexed by accuracy and speed in identifying letters in their positional forms and in ligatures. Directional load could be indexed by right-to-left tracking errors, such as reversals or skipped words, during reading and writing tasks. Inferential load could be indexed by the difference in reading accuracy and speed between texts with and without erabs. Morphological load could be indexed by performance on root identification and derived-form generation tasks. Register load could be indexed by the difference in comprehension between matched spoken-style and formal written-style texts. A subjective mental effort rating adapted for

Urdu could be added for each sub-dimension. These indicators are proposals. Their reliability and validity would need to be established before SCL can be measured with confidence.

First, instruction that explicitly addresses all five SCL sub-dimensions should produce better Urdu literacy outcomes than instruction that treats script demands generically. Learners who receive sub-dimension-specific scaffolding should show faster progress in letter recognition, directional fluency, vowel inference, morphological awareness, and register comprehension than those who receive undifferentiated support.

Second, the SCL sub-dimensions should differentially predict reading and writing performance. Orthographic and directional load should be stronger predictors of early decoding accuracy. Inferential and morphological load should be stronger predictors of reading fluency and comprehension. Register load should be a stronger predictor of performance on formal written tasks. These differential predictions can be tested through psychometric studies that measure each sub-dimension independently.

Third, materials designed according to Phase 2 principles, i.e., consistent Nastaliq typography, integrated vocabulary support, right-to-left layout clarity, and worked examples, should produce lower subjective cognitive load ratings and higher performance than materials that violate these principles. This can be tested through materials comparison studies using validated cognitive load rating scales.

Fourth, the scaffold fading trajectories specified in Phase 3 should be sub-dimension-specific. Learners who have mastered orthographic recognition should not need continued letter-form scaffolding, even if they still need erabs support. Premature removal of scaffolding on one sub-dimension should impair performance on that sub-dimension without affecting others. This prediction has direct implications for the design of responsive instruction and formative assessment tools.

Fifth, the SCL audit mechanism should improve design quality compared to frameworks that apply CLT principles without explicit verification. Designers who use the audit questions should produce materials with lower ECL and more precisely calibrated ICL than those who work from general CLT guidance. This can be tested through design process studies that compare audit and non-audit conditions.

Sixth, the framework's effects should be moderated by learners' prior literacy experience. Learners with prior literacy in another Perso-Arabic script language should show lower baseline SCL on orthographic and directional subdimensions and should require less intensive scaffolding in those areas. This prediction follows from CLT's expertise reversal principle and provides a basis for differentiating instruction by learner background.

8. DISCUSSION

8.1 Theoretical Contributions

The primary theoretical contribution of this article is the SCL construct. By disaggregating the cognitive demands of Urdu literacy into five theoretically distinct sub-dimensions, SCL is intended to provide a level of specificity that general CLT does not currently offer. This specificity is what makes design prescriptions possible and what makes the framework testable. A framework that tells designers to 'reduce ICL' is useful as a reminder; a framework that tells them to reduce orthographic complexity by sequencing Nastaliq forms from isolated to ligature, or to reduce inferential load by providing erabs-marked texts, may be useful as a tool.

The integration of CLT and scaffolding theory is also a contribution, though a more modest one. These two frameworks have been used in parallel for decades without being systematically connected. The present framework makes their relationship explicit: scaffolding decisions are the operational expression of CLT's design principles, calibrated to the learner's current working memory capacity on each specific sub-dimension. This connection may help clarify why scaffolding works and offers a principled basis for deciding when and how to fade it.

The audit mechanism extends a contribution first introduced in the CLT phase-based framework for learning disabilities (Hussain, 2025). Adapting it to the Urdu literacy context suggests that the audit logic may not be domain-specific; it could be applied wherever CLT principles need to be translated into explicit, checkable design decisions.

8.2 Implications for Research

The most immediate research priority is empirical testing of the SCL construct itself. Do the five sub-dimensions operate as theoretically distinct sources of cognitive load? Can they be measured independently? Do they predict literacy outcomes differentially? Psychometric studies that develop and validate SCL measurement instruments would be a valuable first step, both for testing the framework and for providing formative assessment tools that practitioners can use.

Beyond validation of the construct, comparative intervention studies are needed. Do learners who receive instruction designed according to this framework achieve better outcomes than those who receive standard Urdu literacy instruction? Within framework studies, does addressing all three phases produce better outcomes than addressing one or two? These questions require experimental or quasi-experimental designs with adequate sample sizes and validated outcome measures.

The framework also raises questions about the relationship between Urdu literacy and literacy in other Perso-Arabic script languages. Do learners with Arabic or Persian literacy backgrounds show lower SCL on orthographic and directional sub-dimensions? If so, how should their instruction differ from that of learners with no prior script knowledge? These questions have practical implications for Urdu instruction in multilingual settings.

8.3 *Implications for Practice*

For curriculum designers and teachers, the framework offers something that general literacy guidance does not: a script-specific lens for analyzing why Urdu literacy may be hard and a structured process for addressing that difficulty through design. The SCL profile in Phase 1 is particularly useful. It gives designers a way to analyze instructional materials not just for content difficulty but for the specific cognitive demands that the script places on learners, something that standard readability measures and difficulty indices do not capture.

The scaffolding calibration table (Table 4) can function as a practical decision support tool. The audit questions at each phase can be used not only in initial design but also in materials review as a checklist for evaluating existing Urdu literacy materials against the framework's principles. This has obvious utility for teacher professional development and for the review of published Urdu textbooks and resources.

8.4 *Relationship to Related Frameworks*

This framework is designed to complement existing approaches to Urdu literacy instruction. It does not displace methods like explicit phonics instruction, shared reading, or language experience approaches. Rather, it provides a cognitive design logic that can strengthen any of these methods by making their relationship to cognitive load explicit and verifiable.

The framework also connects forward to research on Urdu literacy for learners with specific learning disabilities. The CLT phase-based framework for LD students (Hussain, 2025) established the general logic of phase-based, auditable CLT design. The present framework applies and extends that logic to the script-specific demands of Urdu. A third framework addressing the intersection of Urdu literacy, CLT, and learning disabilities will be needed to close this gap fully. That framework builds on both this article and its predecessor.

8.5 *Summary*

The framework presented here offers a principled, script-sensitive approach to designing Urdu literacy instruction. Its key contributions are the SCL construct, the integration of CLT and scaffolding theory through a structured phase-based process, and the embedded audit mechanism that is intended to make design decisions more explicit and checkable. It is a theoretical model that requires empirical testing, but it provides both a research agenda and a proposed design tool for those working in Urdu literacy now.

9. LIMITATIONS AND FUTURE DIRECTIONS

Several limitations should be acknowledged. The SCL construct is theoretically derived, not empirically validated. The five sub-dimensions are grounded in the linguistic and cognitive literature, but their independence as cognitive constructs has not been demonstrated

through psychometric research. It is possible that some sub-dimensions are more correlated than theorized, e.g., orthographic and directional load may be closely linked in early literacy, operating as a single perceptual challenge rather than two distinct ones. Empirical testing is essential. A related limitation is the boundary between script demands and wider language demands. Morphological and register load in particular may be better described as language-related than script-related, and future work should test whether they belong under SCL or should be treated as a separate language-demand construct. Because intrinsic load also depends on learner expertise, the same feature may impose little load on a learner with prior experience of a Perso-Arabic script.

The framework does not account for individual differences in cognitive architecture. Working memory capacity varies across individuals, and this variation interacts with SCL in ways the framework does not specify. Learners with greater working memory capacity may navigate SCL demands more easily, even without scaffolding. Learners with specific cognitive profiles (including those with learning disabilities) may face SCL demands in ways that require modification of the framework's standard scaffolding trajectories. In practice, this means that the SCL profile should be repeated for individual learners and that fading decisions should follow each learner's evidence and not a fixed schedule.

The framework assumes that Urdu is the primary or target literacy language. Many learners in Pakistan and in diaspora communities are developing literacy in Urdu alongside literacy in another language, e.g., English, Sindhi, Punjabi, or others. Cross-linguistic transfer effects, both facilitative and interfering, are not addressed in this framework. They should be. Until they are, the SCL profile in Phase 1 should record learners' literacy in other languages and scripts, since transfer may lower some demands, as with Arabic or Persian literacy, and may raise others, such as left-to-right reading habits.

The illustrative examples and scaffolding strategies described in the framework have not been field-tested. They are derived from theoretical principles and practitioner knowledge, but their effectiveness in actual classrooms remains to be demonstrated.

Future research should prioritize, first, the development and validation of SCL measurement instruments (both self-report cognitive load scales adapted for Urdu literacy contexts and performance-based measures that can index load on each sub-dimension independently). Second, comparative studies that test the framework against standard Urdu literacy instruction are needed. Third, research on the framework's applicability across different learner populations, e.g., young children, adult learners, heritage language learners, and learners with disabilities. This will establish its generalizability and identify where it needs to be adapted. These priorities are ordered by dependency. Without validated measures of the sub-dimensions, comparative intervention studies cannot show which parts of the framework drive any effects, and applicability across populations cannot be judged.

The framework should also be translated into practical design tools: SCL profiling checklists, audit forms, materials review rubrics, and scaffolding decision trees. These tools

are what will make the framework useful to teachers who are not researchers. Developing and field-testing them is an important next step.

10. CONCLUSION

Urdu literacy instruction has received comparatively little attention from cognitive science (Ikhlaque & Yousaf, 2025). The structural properties of the Urdu script (its Nastaliq orthography, right-to-left directionality, absent short vowels, morphological depth, and register complexity) are likely to create cognitive demands that matter for instruction Yet these demands have not been theorized in a way that connects to instructional design.

This article has attempted to build that connection. The Script Complexity Load construct names the cognitive demands of Urdu literacy at the level of specificity needed for design. The three-phase framework translates CLT and scaffolding theory into a process that designers can follow, check, and improve. The SCL audit mechanism is intended to make that process checkable.

The framework is a beginning. It offers a theoretical foundation for a body of empirical work that has not yet been done, i.e., studies that measure SCL, test the framework's predictions, and refine the scaffolding calibrations it proposes. That work is needed. Urdu is spoken by over 70 million people as a first language (Britannica Editors, 2026) and by many more as a second or additional language. Improving the quality of Urdu literacy instruction on principled, theoretically grounded foundations matters for a significant portion of the world's learners. Early literacy is the gateway to the rest of the curriculum. Where Urdu is the national language or a medium of instruction, learners who struggle to decode and write Urdu are likely to fall behind in other subjects as well, and weak foundational literacy is associated with lower school progression and attainment and with fewer opportunities for later study, employment, and civic participation. For learners with disabilities and other learning difficulties, who are already at risk of exclusion, instruction designed with cognitive demands in mind may make the difference between access and exclusion (Dutt & Ahuja, 2025). A framework that helps designers see where the difficulty lies, and what support to provide, is therefore of practical value once it has been tested.

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