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Designing for Cognitive Efficiency: An Empirical Study of Teacher Experiences in an Online Learning Platform

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Abstract

Cognitive load is a critical factor to consider in digital learning, as it directly influences learner engagement, comprehension, and overall success. By managing cognitive load effectively, digital platforms can create more efficient and supportive learning experiences that enhance self-efficacy and learning outcomes. This study investigates the cognitive load experienced by learners in an online learning system, with a focus on understanding how cognitive load, specifically extraneous, intrinsic, and germane loads affect the learning performance. While cognitive load plays a significant role in explaining individual learning differences, there has been limited empirical research on measuring it in the context of online learning platforms. This research aims to assess cognitive load levels, particularly among teachers, associated with the "The Digital Educator: A Primer (English)" course hosted in an online learning platform, FramerSpace, using cognitive load scale instrument. Data from self-reported questionnaires and semi-structured interviews were collected from 30 middle school teachers (ages 25–50) at a school in Delhi, India. The findings indicated that the course offered less intrinsic load and extraneous load and greater germane load. Additionally, the study also identifies the pain points from the users that may hinder the learning performance. This study presents instructional design strategies grounded in Cognitive Load Theory (CLT) and the Cognitive Theory of Multimedia Learning (CTML) principles to minimize cognitive load in e-learning platforms. Additionally, it explores how insights and results can inform the design of more cognitively aligned and potentially more effective courses.

Keywords: Cognitive load theory, E-Learning, Instructional Design, Learning Experience Design, Multimedia Learning Principles, Online learning platforms

1. Introduction

Advancements in digital technology have expanded learning opportunities, enabling learners to engage with interactive multimedia content and navigate courses in a self-paced format. Knowledge acquisition during learning is closely linked to how effectively learners manage their cognitive resources, given the inherent limitations of working memory. As such, understanding and regulating cognitive load is essential in the context of instructional design and educational research (Brünken et al., 2010) (Sweller,1988). Optimal learning takes place when learners' working memory has sufficient capacity to process and integrate new information without being overwhelmed. Existing studies highlight that cognitive load is instrumental in accounting for individual learning variability and serves as a foundational principle for developing learning environments that are cognitively aligned with human information processing (Moreno & Park 2010). Cognitive load consists of three distinct but interrelated components as intrinsic, extraneous, and germane load. Since these types of loads are additive, their total cognitive demand must be kept within the boundaries of working memory capacity to support effective learning (Leppink et al., 2010). Therefore, the effectiveness of learning and problem-solving is bounded by the total cognitive load, which encompasses all three types. Research in multimedia learning indicates that optimal learning is achieved by reducing unnecessary extraneous cognitive load that disrupts the learning process, while enhancing the mental effort dedicated to organizing knowledge and developing skills (Mayer & Moreno, 1998).

Learners often experience high cognitive load due to irrelevant information, poorly structured materials, and limited familiarity with digital platforms (Clark & Mayer, 2023). This issue is especially prominent among novice learners, underscoring the need to study cognitive load in multimedia-rich e-learning environments (Van Merriënboer et al., 2006). Digital technologies can either reduce or increase cognitive load depending on how learning processes are supported (Leppink et al., 2010; Clark & Mayer, 2023). As more complex content is delivered through computer and mobile interfaces, applying instructional design principles grounded in CLT becomes essential for meaningful learning and knowledge transfer (Curum & Khedo, 2021). Building on this, the CTML explains how learning improves when instructional materials are designed to align with how the brain processes visual and auditory information.

Although previous studies Huang et al., (2016) and Hwang et al., (2013) have examined the effects of e-learning systems and traditional instructional strategies on learners' performance and cognitive load, there is a notable gap in research focusing on the cognitive load experienced by teachers during digital professional development. To address this gap, the present study investigates the cognitive load associated with an online course titled "The Digital Educator – A Primer (English)," designed to help teachers effectively integrate digital technologies into realistic, engaging, and pedagogically sound learning environments.

Grounded in CLT, this research explores the types of cognitive load teachers experience while engaging with the course. It also evaluates how the course design aligns with the principles of the CTML. Thirty middle school teachers participated in the study. Data were collected using the Cognitive Load Scale questionnaire (Choi & Lee, 2022), while participants' insights were gathered through semi-structured interviews with a subset of participants.

The data collected were analysed to assess the relationship between different types of cognitive load and teachers' learning performance. Additionally, participants' feedback of the course design helped to identify key pain points, leading to targeted recommendations for enhancing the course's effectiveness and reducing unnecessary cognitive burden.

2. Literature Review

The literature review is divided into two sections. The first outlines CLT, which explains how working-memory limitations affect learning and highlights the need to manage intrinsic, extraneous, and germane cognitive load through effective instructional design. The second focuses on the CTML, which describes how learners process information through visual and auditory channels and presents evidence-based principles for designing multimedia materials that reduce unnecessary load and promote meaningful engagement.

2.1 Cognitive Load Theory: A Framework for Effective Learning Design

Effective learning depends on managing cognitive load within a learning system (Brunken et al., 2003; De Jong, 2010; Moreno, 2010). In digital environments, understanding learners' cognitive load is essential for designing instruction that supports meaningful and efficient learning (Mayer & Moreno, 1998). Sweller (1988) identified three types of cognitive load: intrinsic, extraneous, and germane. Intrinsic load reflects the inherent complexity of content and learning objectives, increasing when material is perceived as difficult, and is shaped by learners' prior knowledge and experience (Sweller, 2010). In professional learning contexts, such as teacher development courses, intrinsic load may be intensified because educators must simultaneously learn new concepts while considering how to apply them in classroom practice.

Recent research on teacher professional development suggests that teachers engage with digital learning content both as learners and practitioners, which can increase cognitive demands if instructional materials are not well scaffolded (Philipsen et al., 2019). Online professional development environments therefore require careful design to ensure that complexity is introduced gradually and remains aligned with teachers' professional needs (Darling-Hammond et al., 2017).

Recent usability-focused studies emphasize that extraneous cognitive load is not only caused by instructional content but also by platform design and interface complexity. In digital learning environments, inconsistent layouts, high interaction demands, and poor usability can significantly increase cognitive burden (Baceviciute et al., 2021). This is particularly relevant in mobile and teacher-facing professional learning platforms, where smooth navigation supports sustained engagement (Martin et al., 2020). When intrinsic load is balanced and extraneous load minimized, learners can engage more effectively and develop a stronger sense of belonging (Kalyuga, 2011).

Germane load refers to the mental effort invested in organizing and integrating new information into existing knowledge structures (Van Merriënboer et al., 2006). It supports deeper learning and is influenced by motivation, engagement, and adaptability, and can be measured through emotional involvement and perceived contribution (Paas et al., 1994). Cognitive overload occurs when task demands exceed cognitive capacity (Sweller, 1988). In digital learning environments, optimizing instructional design is crucial to prevent overload and enhance learning outcomes.

2.2 CTML Principles: Designing for How the Mind Learns

This study applies selected principles from CTML to examine how digital learning design can improve clarity, accessibility, and overall learning efficiency. These principles were used to assess the course and identify opportunities for strengthening engagement and comprehension.

The segmentation principle involves presenting multimedia content in smaller, learner-controlled chunks (Mayer & Moreno, 2003). Research shows that by giving learners time to process information gradually, segmentation helps manage cognitive load (Mayer & Moreno, 2003, 2010) (Spanjers et al., 2011).

The pretraining principle introduces key concepts before complex material, enabling learners to form foundational understanding and reducing cognitive load (Mayer & Moreno, 2003, 2010). In the course, pretraining prepares learners to navigate advanced topics more effectively.

The modality principle emphasizes presenting information through multiple channels, such as combining visuals with narration, to take advantage of separate processing pathways in working memory (Sweller et al., 2019). Earlier research shows auditory delivery may particularly support learners with lower working-memory capacity (Sweller, 1988). Multimedia-rich environments further enhance accessibility and focus (Curum & Khedo, 2021).

The redundancy principle advises limiting unnecessary material to avoid overwhelming learners. Mayer and Moreno (2010) found that in the absence of animation, combining narration with on-screen text can improve learning. This is especially relevant in mobile learning, where streamlined content supports both cognitive efficiency and technical performance.

The seductive details effect warns against including interesting but irrelevant content, which can distract learners and add extraneous load (Harp & Mayer, 1998). However, under low cognitive load, narrated seductive details may enhance learning (Park et al., 2015). Engaging elements must therefore be used carefully and aligned with learning goals.

Applying CLT and CTML principles in online learning helps streamline content, improve comprehension, and strengthen long-term retention. Accordingly, this study evaluated the "Digital Educator – A Primer (English)" course with teachers as the primary users, examining levels of intrinsic, extraneous, and germane cognitive load and exploring their relationship with learning performance. The course was also analysed using CTML principles, and recommendations were developed based on the findings.

3. Methodology

3.1 Participants

The study involved 30 middle school teachers (ages 25–50) from various subject areas at a reputed English-medium school, recruited through convenience sampling. All participants completed an online professional development course, The Digital Educator – A Primer (English) and provided informed consent. After each module, they completed a self-reported questionnaire embedded at the end of the module. Ethical approval was obtained from the institutional review committee, as no sensitive or personally identifiable data were collected.

3.2 Course Overview

"The Digital Educator – A Primer (English)" is a professional development course designed to empower teachers with the knowledge and skills to integrate digital technologies into their teaching practices effectively. Aligned with global digital competency standards such as DigCompEdu (Redecker, 2017) and UNESCO ICT-CFT (UNESCO,2018), the course adopts a neuroscience-informed, whole-brain approach to help educators build authentic, inclusive, and engaging learning experiences. The modules are named as “Quest”. The course consists of a total of six Quests and their summary is given in Table 1.

Table 1. Course Overview – Module Structure and Content

Modules	Title	Description
Quest 0	Introduction	- Introducing course structure, objectives, and pedagogy - Presents the "whole brain" model of learning (emotional + rational) - Promotes reflection on digital confidence - Includes digital competence self-assessment
Quest 1	Understand Digital Pedagogy	- Explores learner variability and its implications - Highlights the role of empathy and SEL in teaching - Distinguishes digital pedagogy from basic ICT - Focus on purposeful use of technology for inclusive teaching
Quest 2	Design Learning Experiences	- Introduces the Universal Design for Learning (UDL) framework - Explains three UDL principles: engagement, representation, and expression - Helps identify learning barriers - Maps digital tools to UDL checkpoints
Quest 3	Navigate the Digital Space	- Covers digital citizenship, digital identity, and online safety - Promotes ethical and respectful online behavior - Teaches strategies for data protection and digital responsibility - Encourages participatory digital practices
Quest 4	Hybrid Learning Environmen ts	- Explores effective design of hybrid (blended) learning - Offers strategies for balancing online and in-person modalities - Encourages reflection on when to use digital tools vs. face-to-face methods - Supports continuity and differentiation
Quest 5	Reflect and Share Your Learning	- Promotes reflective practice and consolidation of learning - Revisits initial goals and tracks growth in digital competence - Encourages sharing lesson plans and strategies with peers - Provides professional learning networks

3.3 Procedure of the Study

The course was introduced to the participating teachers through a brief in-person orientation session lasting approximately one hour. During this session, participants were guided through the process of signing up, logging into the FramerSpace platform, and enrolling in the course. As the course was designed to be self-paced and delivered entirely online, participants were given a period of three weeks to complete all modules. Throughout the course, learners progressed independently and, upon completing each module, were required to fill out the Cognitive Load Scale (CLS) questionnaire to report their perceived cognitive load. Learners could also track their progress and view their individual scores for each completed module through the learner dashboard. Upon course completion, a series of one-on-one semi-structured interviews were conducted with a subset of participants to explore their learning experiences in more depth. These interviews focused on aspects such as cognitive load, challenges encountered, and suggestions for improving the course. This mixed-method design provided comprehensive insights into how learners engaged with the course content and navigated the digital learning environment.

3.4 Data Collection

3.4.1 Research Instrument

To measure the cognitive load experienced by teachers during the course, the Cognitive Load Scale (Choi & Lee, 2022) was used as the primary research instrument. The scale has established validity and reliability in online learning environments. The CLS questionnaire used for the study is shown in Table 2. Each item in the questionnaire was designed to evaluate a specific type of cognitive load—intrinsic, extraneous, or germane—in relation to the module just completed. Specifically, Items 1–3 assessed intrinsic load, Items 4–6 targeted extraneous load, and Items 7–9 measured germane load. Participants were asked to indicate their level of agreement on a five-point Likert scale, where 1 signified "no load" and 5 represented "high load." For analysis, cognitive load scores were computed by summing the item responses within each subscale, resulting in separate total scores for intrinsic, extraneous, and germane load for each module. We employed a within-subjects repeated-measures design. At the end of each module, teachers completed the CLS, which was embedded directly within the learning platform.

Reliability analysis showed that the 9-item instrument had good internal consistency (Cronbach's $\alpha = .79$), suggesting that the items consistently measure the intended construct.

Table 2. CLS Questionnaire used for the study

Sno	Questions
1	The topics covered in this module were very difficult in terms of my previous knowledge, skills, and educational experiences
2	The concepts and definitions discussed in this module were complex in terms of my previous knowledge, skills, and educational experiences
3	Module objectives, quizzes, and activities in the module were difficult in terms of my previous knowledge, skills, and educational experiences
4	The UI of the module screen is designed for an intuitive and easy to learn experience.
5	The functions for learning activities in this e-learning course (e.g., buttons and menus for question-and-answer session, discussion forum with other learners, module progress and learning dashboards) are conveniently provided
6	I felt comfortable navigating the platform and participating in activities, which enhanced my motivation and sense of belonging within the learning community
7	How much did you concentrate and be engaged during the module?
8	How much did you put in in terms of mental and emotional effort and time for this module?
9	Did this module enhance the motivation of learning new knowledge, understanding, and application of skills in your domain?

After collecting cognitive load measures, we conducted semi-structured interviews with participants at the end of the course to explore participants' experiences of cognitive load and their perceptions of course design features that may have influenced it. Questions such as "Can you describe your experience while engaging with the course?" and "Which design elements supported your learning?" explored perceptions of course structure, content delivery, interactivity, and navigation. Interview data were analyzed using a descriptive, interpretive thematic approach (Braun & Clarke, 2006; Merriam & Tisdell, 2016). The primary researcher identified excerpts aligned with themes derived from the expert analysis, enabling triangulation between learner perspectives and expert review (Patton, 2015). Two additional researchers with expertise in educational technology and learning design principles independently coded selected excerpts against the identified themes in the expert review. Interrater reliability was calculated using Cohen's kappa, yielding a coefficient of κ =0.6 (Landis & Koch, 1977). Discrepancies were resolved through discussion, and minor refinements were made to the thematic structure.

3.5 Statistical Analysis

3.5.1 Cognitive Load Analysis across each module

From the self-reported questionnaire data was assessed for normality using the Shapiro-Wilk test. Since the test results indicated that the assumption of normality was violated ($p < 0.05$), the Friedman test was applied to determine whether there were statistically significant differences between the groups.

Table 3. Cognitive Load and their Means

Modules	**Intrinsic Load**		**Extraneous Load**		**Germane Load**	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Quest 0	7.09	3.06	7.71	2.46	11.47	2.64
Quest 1	8.10	2.50	7.37	2.34	11.41	2.58
Quest 2	8.9	2.51	6.93	2.20	11.3	2.51
Quest 3	8.55	2.69	7.86	2.02	10.5	1.92
Quest 4	9.05	2.81	7.75	1.83	10.36	2.05
Quest 5	9.32	1.11	8.07	1.37	9.89	1.55

Intrinsic Load – A Friedman test was conducted to compare intrinsic load across six course modules (Q0–Q5). The test was not statistically significant, χ^2 (5) = 5.44, p = .365, indicating no significant differences in intrinsic load between modules. The effect size was very small (Kendall's W = .05).

Extraneous Load – A Friedman test was conducted to compare extraneous load across six course modules (Q0–Q5). The test was not statistically significant, $\chi^2(5) = 6.21$, p = .286, indicating no significant differences in extraneous load between modules. The effect size was very small (Kendall's W = .06).

Germane Load - A Friedman test was conducted to compare germane load across six course modules (Q0–Q5). The results indicated no statistically significant differences between modules, $\chi^2(5) = 9.93$, p = .077. The effect size was small (Kendall's W = .10).

Figure 1 illustrates the distribution of cognitive load scores namely intrinsic, extraneous, and germane across different modules Quest 0 to Quest 5 (depicted as Q0 – Q5), represented as position groups. Each boxplot displays the spread and central tendency of scores for each cognitive load type within the respective module.

For the intrinsic load, a wider variability is observed across groups, particularly between Quest 0 and Quest 2. This suggests that learners in these modules experienced varying levels of inherent task complexity.

The extraneous load remains relatively stable across all modules, with most scores clustering between 6 and 10. However, to ensure effective instructional design, extraneous load should ideally be minimized, as it represents unnecessary mental effort that does not contribute to learning. The presence of moderate extraneous load across modules suggests that there is still room to improve the instructional materials and delivery methods to reduce irrelevant cognitive processing and better support learners' focus on essential content.

In contrast, the germane load shows higher median scores, especially in modules Q0, Q1, and Q2, indicating that participants in these groups invested more cognitive effort in schema construction and meaningful learning. In the later modules (Q4 and Q5), the distribution appears more concentrated with slightly lower medians, which may suggest a reduction in cognitive engagement or a shift toward more familiar or less demanding content.

These patterns suggest a shift in cognitive engagement across modules, with earlier modules inducing higher variability in intrinsic and germane load, and later modules showing more uniformity across cognitive load types. These trends can inform future instructional design to balance difficulty and engagement more effectively.

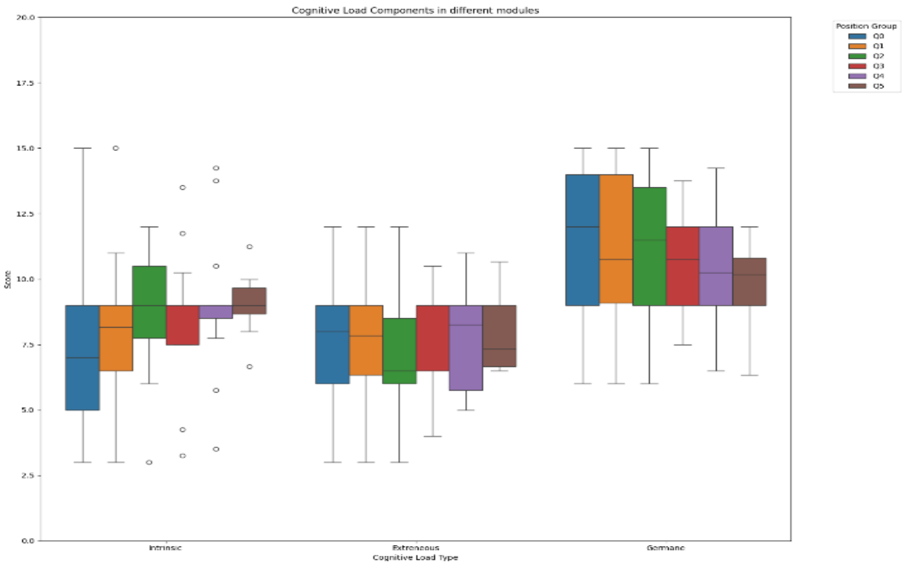

Figure 1. The cognitive load components for different modules

3.5.2 Correlation Between Cognitive Load Components and Learning Performance

In this study, learning performance was defined as the assessment score obtained by teachers in each module. These scores were extracted from the learning dashboard data of the digital platform. Pearson's correlation coefficient (r) was computed to examine the relationship between learning performance and the different types of cognitive load across modules. The analysis was conducted at the module level, where aggregated scores represented independent observations rather than repeated measurements of the same individuals across time. Because the unit of analysis was the module (Quest) and not within-participant longitudinal change, the assumptions underlying repeated-measures correlation (specifically modelling within-subject dependencies) were not applicable. Therefore, Pearson's correlation was deemed appropriate for the present analysis.

Table 4. Correlation Analysis between Learning Performance and Cognitive Load

Learning Performance	Intrinsic Load	Extraneous Load	Germane Load
Quest 0	-0.454281	0.301759	-0.190116
Quest 1	-0.346346	-0.195064	-0.167307
Quest 2	-0.273559	0.183769	-0.166937
Quest 3	0.027335	-0.254414	0.350750
Quest 4	0.109874	-0.290027	0.253503
Quest 5	0.030965	-0.236696	0.192598

In several modules (Quest 0, Quest 1, Quest 2), intrinsic load shows a negative correlation with learning performance, with the strongest negative value in Quest 0 ($r = -0.454$). This suggests that when the perceived difficulty of the learning content increased, performance tended to decrease, indicating that high intrinsic load may hinder learning outcomes if not adequately supported.

Extraneous load also generally shows negative correlations in most modules (such as Quest 1: $r = -0.195$, Quest 3: $r = -0.254$, Quest 4: $r = -0.290$), aligning with cognitive load theory's principle that unnecessary mental effort detracts from learning. These results highlight the importance of minimizing extraneous load through well-structured instructional design.

In contrast, Germane load shows positive correlations with academic performance in most modules (such as Quest 3: $r = 0.351$, Quest 4: $r = 0.254$, Quest 5: $r = 0.193$), implying that learners who invested more effort in meaningful learning and schema construction tended to perform better. This supports the role of germane load in promoting deep cognitive processing and better achievement.

These findings align with CLT, which suggests that high intrinsic and extraneous load can hinder learning, while germane load promotes deeper understanding (Sweller, 2011; Leppink et al., 2015). The negative impact of intrinsic and extraneous load on performance, alongside the positive effect of germane load, highlights the importance of instructional design. Simplifying complex content, removing irrelevant information, and encouraging deeper processing can optimize learning and engagement in digital environments.

3.6 Discussion

This section analyses the cognitive load implications of the course using the CTML principles. The analysis is based on two sources: expert reviews by instructional designers assessing overall course structure, and feedback from teachers identifying challenges at the module (Quest) level. The findings are presented in two parts as overall design strengths and limitations, followed by specific module-level design issues that may have contributed to cognitive overload.

3.6.1 Course-Wide Design Strengths and Limitations

The following strengths and limitations were identified through a comprehensive review of the course conducted by two instructional design experts. Their analysis focused on the overall structure and design of the course, using Mayer's multimedia learning principles as an evaluative framework.

Segmentation Principle - The course's modular structure supports the segmentation principle by organizing content into distinct Quests (Quest 0–Quest 5), allowing for clear pacing and thematic focus. However, some modules, particularly Quest 2 and Quest 5, lack sufficient internal chunking. Learners are often exposed to theory, multimedia content, and tool demonstrations in quick succession, which may increase cognitive load and make it harder to integrate complex concepts such as UDL checkpoints and assessment strategies. For example, the 40-minute webinar in Quest 2 could be divided into shorter segments to improve retention and reduce cognitive strain.

Pretraining principle – This principle is applied effectively in Quest 0 and Quest 1, where foundational concepts such as digital pedagogy and learner variability are introduced through self-assessments and affective check-ins that support learner readiness. However, Quests 2 and Quest 3 introduce technical tools in which learners are redirected to external tool websites without in-platform guidance. The lack of walkthroughs or examples may increase both intrinsic and extraneous cognitive load, especially for novice learners.

Modality principle - The course incorporates multiple modes of delivery, including video, text, and interactive visuals, which generally support dual-channel processing. However, in Quest 5, a video on assessment presents on-screen text, narration, and animation simultaneously. In this case, the narration largely repeats the on-screen text while learners also attend to animated visuals. This combination may place additional demands on the visual channel, as text and animation compete for attention, potentially limiting effective use of the auditory channel.

Seductive Details Effect – The course largely avoids irrelevant or decorative content. However, Quests 0 and Quest 1 include animated graphics, emojis, and decorative interactive elements in Genially that may distract learners from the main learning goals. Similarly, in Quest 2, extensive tool lists and visual embellishments without clear instructional relevance can divert attention, increasing cognitive load, especially for novice learners.

3.6.2 Module-Specific Design Issues Contributing to Cognitive Load

The following design issues were identified based on feedback data gathered from teacher interviews conducted after they completed the course. These insights reflect participants' perceptions of specific elements within individual modules that contributed to increased cognitive load during their learning experience.

Overload Due to Excessive Hyperlinking and Navigation Requirements - The course design imposes a significant extraneous cognitive load by requiring learners to frequently navigate between multiple external platforms such as Padlet, Genially, and YouTube. This practice violates the coherence principle, as frequent redirection fragments learners' attention and increases cognitive switching costs. One participant remarked, "There were too many hyperlinks. I wasn't sure if I should click on them. I was worried some of them might lead to unsafe or fraudulent sites." Another participant shared, "I felt lost at times because there were so many links, I wasn't sure which ones were actually important for the module." The redundancy principle is also compromised, with repetitive and often distracting instructions such as "save answers" or "mark as done" that do not support meaningful learning. These design issues collectively elevate extraneous cognitive load, thereby diminishing the mental resources available for processing essential learning content.

Too Many Open-Ended Reflection Tasks Without Feedback - Many reflection prompts were broad and open-ended, requiring high levels of articulation that may have burdened less experienced or non-native learners. Questions such as "How do you feel now?" or "What are your learners' variability traits?" were often presented without examples or guidance, leaving learners unsure of what was expected. One participant noted, “I spent more time trying to understand the question than actually reflecting,” while another said, “I wasn’t sure how deep I should go.” This lack of scaffolding violated the pretraining and segmenting principles, increasing extraneous cognitive load. The absence of feedback after submissions further added to uncertainty, as one teacher shared, “I didn’t know if I had applied the concepts correctly.”

Redundant Interface Instructions - Repeated instructions such as “Don’t forget to hit the save button!”, “Don’t forget to click the ‘mark as done’ and lock this module!” appear often and break the flow of content. One participant commented, “I felt like I was constantly being told what button to press instead of focusing on the actual content”. The redundancy principle is overridden as administrative prompt such as these interrupts learning. They shift attention from conceptual content to procedural overhead.

Dense or Overlapping Information Presentation - The course content frequently presents multiple layers of information such as theoretical frameworks like UDL, SEL and neuroscience, digital tools, instructional examples, and learner tasks within a single, continuous scroll. This design lacks visual hierarchy, summarization, or structural breaks, thereby violating the segmenting and coherence principles of multimedia learning. Notably, some of the users specifically pointed out that complex concepts were densely packed into a single module, which further increased the difficulty and made it challenging to process and retain the information effectively. The simultaneous presentation of diverse and conceptually rich content without clear organization results in cognitive cluttering as a result learners lose track of the central theme and experience fatigue.

Unclear or Inconsistent Task Instructions - Several activities used vague prompts such as “Explore the block” or “Click on the yellow circles” without sufficient explanation or consistent formatting. Interactive elements created with tools like Genially or Padlet often lacked clear guidance, violating the signalling principle. As one participant noted, “There was no consistency in the prompts, so I ended up spending more time figuring out how to interact with the activity than actually learning from it.” This ambiguity increased extraneous cognitive load by shifting attention away from learning. Some tasks also required significant time (20–40 minutes) without providing immediate feedback or support. For example, learners were asked to design and upload an assessment aligned with UDL principles, but the platform offered no guidance on evaluation or progress. Such lack of clarity and feedback may reduce motivation, lead to disengagement, and limit germane cognitive processing.

Cognitive Overload from Tool Repositories - The course presents an extensive repository of more than fifteen categories of digital tools and asks teachers to explore unfamiliar tools themselves. While beneficial, selecting and applying the right tools to match learner needs requires significant mental effort, especially if prior digital familiarity is low. Both the segmenting and the pretraining principles are violated in this case. Without guided exploration or narrowed options, this may feel more like an open-ended search exercise than a learning task. One teacher suggested “Providing examples of tools under each category such as subject-specific tools, creative tools, presentation tools, and collaboration tools would make the exploration more targeted and meaningful.”

Identified User Interface Design Challenges in the Course Platform - Several user interface (UI) design challenges were identified in the course platform that may hinder the overall learner experience. Action buttons such as "Save" and "Update" are visually indistinct from surrounding text, making them difficult to locate and interact with efficiently. The platform appears to lack a consistent UI style guide, resulting in inconsistencies in font usage, button styles, and layout structures across modules. Embedded media elements, such as videos and Padlets, are presented without thumbnails or descriptive previews, requiring user interaction before the content's nature or relevance becomes clear. Navigation is also impeded by the need for excessive scrolling, as users often must move back and forth across long pages to locate critical buttons or revisit earlier content. On mobile devices, interactive Genially elements are rendered at sizes that are too small for practical use, requiring responsive scaling to ensure usability and readability on smaller screens.

3.6.3 Recommendation

Based on the insights gathered from the analysis and user feedback, several recommendations have been developed to enhance the learning experience and reduce cognitive load. (i) Segment within-module content into smaller, clearly labelled units with pause points to support pacing and reduce cognitive overload. (ii) Introduce foundational concepts before complex tasks using pretraining strategies like guided walkthroughs, vocabulary primers, and examples. (iii) Avoid redundant multimedia by ensuring that narration and on-screen text complement rather than duplicate each other. (iv) Minimize decorative elements (e.g., emojis, animations) that do not support learning to reduce distraction and maintain focus. (v) Streamline navigation by embedding key resources within the platform when possible and using clearly labelled, trustworthy external links only when necessary. (vi) Provide guidance and feedback for open-ended and self-assessment tasks, by including hints, or automated responses to help learners respond meaningfully. (vii) Standardize task instructions and interactive cues (like icons, highlights) across modules to reduce confusion and cognitive effort. (viii) Curate the digital tool repository by organizing tools into categories and providing representative examples and suggested classroom use cases to support purposeful exploration. (ix) Platform should adopt a consistent UI design system with clear visual hierarchy, responsive layouts, and enhanced media previews to improve usability across devices.

3.6.4 Limitation of the study

This study has limitations. It included only 30 teachers from one school in Delhi and focused on a single online course, limiting the range of learning contexts. Cognitive load was assessed mainly through self-report, which may be affected by response bias and common-method effects. Behavioural or usage-based data were not analysed as this was beyond the study's scope. However, the potential influence of common-method bias was partially mitigated through methodological triangulation, combining learner ratings with participants' reflections and expert review of the course design. Future work could include larger samples, multiple courses, and learning analytics for stronger validation.

4. Conclusion

This study highlights the critical role of cognitive load in shaping the effectiveness of digital learning experiences. By examining teacher experiences while taking an online course, it highlights the importance of minimizing extraneous load, optimizing intrinsic load, and promoting germane load through thoughtful instructional design. The findings provide valuable insights for educators, course designers, and platform developers, offering evidence-based strategies to enhance cognitive alignment and learner engagement in online professional development environments. It contributes to the growing body of work on cognitive load in online learning and reinforces the value of applying CLT and CTML principles to support more effective and efficient learner experiences

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