Pharmacy Education (2026) 26(1) 116 - 126
https://doi.org/10.46542/pe.2026.261.116126

RESEARCH ARTICLE

Assessing student course evaluation comments through the lens of cognitive load theory: Insights for best teaching practices

Mohammed A Islam[1], Afroza Hossain[1], Rahmat M. Talukder[2]

[1] School of Pharmacy, American University of Health Sciences, Signal Hill, California, United States
[2] Department of Pharmaceutical Sciences and Health Outcomes, Ben and Maytee Fisch College of Pharmacy, Texas, United States

Keywords
Cognitive load theory
Faculty and course evaluation
Learning
Pharmacy student
Teaching

Correspondence
Mohammed A. Islam
School of Pharmacy
American University of Health Sciences
Signal Hill
California
United States
mislam@auhs.edu

Abstract

Background: Cognitive Load Theory (CLT) explains how memory processes affect learning and retention. In healthcare education, managing complex knowledge, skills, and behaviours can overwhelm learners, underscoring the need for instructional designs that balance cognitive demands. Faculty and course evaluation (FCE) comments offer qualitative insights into student perceptions of instructional effectiveness. This study applies CLT to analyse FCE comments and identify instructional practices that support effective learning. **Methods:** Student FCE comments in a 3-year accelerated Doctor of Pharmacy (PharmD) programme (2019 – 2023) were anonymised, compiled into a text corpus, and analysed using a literature-derived CLT codebook. Three investigators conducted qualitative analysis to identify recurring cognitive load themes. **Results:** Codes were categorised into extraneous, intrinsic, and germane load elements. The most frequent theme involved instructional practices increasing extraneous load (400 codes), reflecting unnecessary cognitive burden. Supportive and organised teaching practices were linked to reduced extraneous load (321 codes). Simplified explanations and real-life examples were associated with minimising intrinsic load. Interactive and inclusive methods were identified as enhancing germane load (20 codes). **Conclusion:** Findings demonstrate how student experiences reflect CLT principles and offer guidance for improving instructional design. Applying CLT in healthcare education can foster more efficient, engaging, and meaningful learning environments.

Introduction

Cognitive Load Theory (CLT) is an influential framework in educational psychology (Sweller, 2019; Ouwehand, 2025). The interplay between the human memory system and CLT is critical to understanding how effective learning occurs (Paas & Ayres, 2014). The human memory system plays a crucial role in processing, storing, and retrieving information (Camina & Güell, 2017; Loftus & Loftus, 2019). At its core, the system consists of three main components: sensory memory, short-term (or working) memory, and long-term memory (Eggen, 2020). Each component interacts with cognitive processes, substantially influencing learning and information retention (Tyng *et al.,* 2017).

Sensory memory acts as a temporary repository for environmental information, receiving and briefly storing data from visual and auditory channels (Camina & Güell, 2017). Most sensory information remains subconscious until a learner focuses on specific information, at which point it transitions to the next stage (Wang *et al.,* 2022). Working memory, where conscious processing of information occurs, has a limited capacity, typically holding about seven items at a time, and retaining information for about 20 seconds (Baddeley & Hitch, 1974). Working memory is crucial in cognitive functions such as reasoning, comprehension, and learning. Due to its limited capacity, working memory can become easily overloaded, which impacts cognitive performance and learning efficiency (Baddeley, 2012). Consequently, information is either

ISSN 1477-2701 online

discarded or rehearsed and transferred to long-term memory, where information is stored indefinitely. Long-term memory is categorised into explicit memory (personal experiences and general knowledge) and implicit or procedural memory (skills and habits). The information transfer from short-term to long-term memory occurs through encoding, consolidation, and retrieval processes. Effective learning strategies and instructional design facilitate this transfer, ensuring that information is retained and accessible for future use (Widmaier *et al*., 2022).

The CLT is especially relevant in healthcare education, where learners concurrently process various knowledge, skills, and behaviours, often resulting in information overload (Van Merriënboer & Sweller, 2010). CLT emphasises the limitations of working memory and offers a framework for designing instruction that balances three types of cognitive load: intrinsic, extraneous, and germane (Jordan *et al*., 2020; Sweller, 2010). Intrinsic load is tied to the inherent complexity and interactivity of learning material (Sweller, 2010). The level of element interactivity, which refers to how many components of the information material must be processed together, drives this load (Sweller, 2010). For example, learning a drug's mechanism of actions or pathophysiology of a disease imposes a higher intrinsic load than simpler tasks. Moreover, a learner's prior knowledge affects intrinsic load, as those with a prior understanding of the subject matter experience lower cognitive strain than those without it (Sweller, 1994). Extraneous cognitive load is the unnecessary mental effort resulting from poor instructional design and delivery, including unclear instructions, complex presentations, and distractions that disrupt learning (Young *et al*., 2014). Reducing this load is vital for effective teaching, as it frees up mental resources for actual learning (Van Merrienboer & Sweller, 2005). In contrast, germane load represents mental effort directed toward schema construction and deeper learning, which can be fostered through active and engaging instructional strategies (Hadie *et al*., 2018; Sweller, 2010).

Despite its contributions to understanding learning processes, CLT research is hindered by the lack of a standardised, objective metric to assess cognitive load. Existing methods such as self-report surveys, dual-task techniques, and physiological measures are methodologically constrained, resource-intensive, and rarely feasible in classroom settings (Leppink & van den Heuvel, 2015; Ghanbari *et al.,* 2020). This study aims to contribute to bridging this gap by examining students' lived experiences as a qualitative proxy for understanding cognitive load in real-world educational contexts. FCE comments offer a valuable but underutilised source of data, capturing nuanced perceptions of instructional effectiveness, clarity of materials, and barriers to learning that are not easily measured by quantitative instruments.. By systematically analysing qualitative student narrative data through the lens of CLT, this study seeks to illuminate how students' perceptions of instruction align with intrinsic, extraneous, and germane cognitive load. This approach not only illuminates the lived experiences behind cognitive challenges but also offers educators actionable insights into instructional practices that support or hinder learning.

Methods

The study analysed written comments from a convenience sample of 1,267 FCEs drawn from a total of 5,760 evaluations collected from the Office of Institutional Effectiveness and Research in an accelerated 3-year PharmD programme. A total of 89 students across four cohorts completed FCEs between Summer 2019 and Fall 2023, with multiple evaluations provided by the same students over time. This subset was selected because it represented narrative comments, providing a manageable yet information-rich dataset for thematic analysis. The FCE comments were drawn from 45 courses spanning biomedical sciences, pharmaceutical sciences, clinical sciences, and practice-based experiences. Of these, 25 were from the first year, 18 from the second year, and 2 from the third year. This sample allowed for exploration of cognitive load manifestations across multiple domains of pharmacy education, thereby enhancing the transferability and relevance of the findings to diverse instructional contexts. The FCE comments were compiled into a single text corpus that was systematically examined to understand cognitive load in educational settings. From these, instructors' names and other identifying details were redacted to ensure confidentiality. The text comments were compiled into a single corpus and prepared for analysis. Because comments ranged from short phrases (e.g., "*great professor*") to longer reflections, they were segmented into the smallest coherent "*units of analysis*," defined as single, self-contained ideas about teaching or learning, with relevance to CLT kept in mind. This process yielded 804 units. Segmenting by meaning units, rather than whole comments, ensured both brief and extended responses contributed proportionally and allowed for more precise, consistent coding (Kawaguchi-Suzuki *et al.,* 2023). The text data were organised in an Excel spreadsheet for coding and subsequent thematic examination.

The research team comprised two pharmacy educators in academic leadership roles with extensive experience in curriculum development, instructional design, assessment, and qualitative research. The third investigator was a PharmD candidate with formal training in qualitative research. All three investigators had prior publications in qualitative research. Before undertaking the analysis, the investigators participated in a faculty development workshop on CLT and its relevance to health professions education. This training emphasised the distinctions between intrinsic, extraneous, and germane cognitive load as defined in Table I. Drawing on existing literature on CLT and its relationship with teaching and learning practices, an a priori codebook was developed to guide the coding process (Ghanbari *et al.,* 2020; Jordan *et al.,* 2020; Leppink & van den Heuvel, 2015; Van Merriënboer & Sweller, 2010; Young*et al.,* 2014).

Table I: Definitions of cognitive load theory constructs and associated instructional practices and faculty attributes utilised in coding student FCE comments

CLT element	Definition	Instructional factors influencing CLT
Intrinsic cognitive load	Cognitive load inherent to the complexity of learning material; determined by the interactivity of the elements.	**Factors managing intrinsic cognitive load** • Clear sequencing of concepts • Breaking complex tasks into simpler components • Prior knowledge activation • Scaffolding of content **Factors increasing intrinsic cognitive load** • Overly complex content without scaffolding • Lack of alignment between learners' existing knowledge and new content • High complexity tasks presented simultaneously
Extraneous cognitive load	Cognitive load imposed by the instructional design; does not contribute directly to learning objectives.	**Factors reducing extraneous load** • Clear, concise, and organised materials • Avoiding irrelevant information • Consistent presentation formats • Effective multimedia integration (e.g., coherent PowerPoint design) **Factors increasing extraneous load** • Unnecessary information or distractions • Poorly organised or cluttered presentations • Ineffective use of multimedia (e.g., excessive animations, irrelevant visuals) • Ambiguous instructions or unclear expectations
Germane cognitive load	Cognitive load that contributes directly to learning and schema construction; fosters meaningful learning outcomes.	**Factors increasing germane load** • Active learning techniques (discussions, case studies, problem-based learning) • Reflection and self-explanation • Interactive learning environments • Encouraging metacognitive strategies • Facilitation of connections between new and existing knowledge **Factors reducing germane load** • Passive learning environments (e.g., purely lecture-based without interaction) • Lack of opportunities for reflection or critical thinking • Minimal application or real-world relevance of content • Insufficient feedback and guidance from faculty

Thematic analysis was conducted to identify recurring themes related to cognitive load, using a deductive approach. To minimise potential bias stemming from the investigators' positionality, coding was performed independently by three investigators independently. The data were coded by systematically reading and tagging each unit of analysis with relevant codes, which were then organised into categories corresponding to the predefined themes in the codebook. Codes were first grouped into descriptive categories (e.g., "*poor instructional quality*," "*content overload*"), which were then abstracted into broader themes aligned with CLT elements. Any discrepancies were resolved through discussions and consensus meetings. The consensus coding was employed as a recognised strategy to enhance analytic rigour, ensure interpretive consistency, and preserve the contextual nuance of qualitative data (MacPhail *et al.,* 2016; Olmos-Vega *et al.,* 2023). The analysis was designed to interpret the entire dataset through the CLT framework rather than contrast specific subgroups; therefore, results are reported as absolute frequencies to directly represent how often particular themes appeared across all student comments. All the data were entered in an

Excel worksheet. To maintain methodological rigour, the authors adhered to established qualitative research guidelines (Kawaguchi-Suzuki *et al.,* 2023). This study was granted exempt status by the American University of Health Sciences Institutional Review Board.

Results

Analysis of the students' FCE comments revealed patterns related to instructional quality, course organisation, and engagement. These experiences were not expressed by students in terms of cognitive load constructs but were subsequently interpreted by the research team using CLT as a guiding framework (Table I). Through this lens, student feedback was coded to instructional practices associated with extraneous, intrinsic, and germane load.

The most frequently identified theme (400 codes) involved reports of instructional practices that hindered learning. Students described ineffective teaching, unclear guidance, inconsistent objectives, disorganised delivery, conflicting materials, content overload, unfair or poorly designed assessments, and communication problems (Table II). For example, one student remarked, "*Worst class ever, very unorganised unprofessional instructor, waste of time over watching YouTube videos without sounds, and I didn't learn anything in this class*." Another added, "*In the class he is the solo speaker which makes the class boring. He does not give us any break and it makes the second part of the class even harder while he is the only one talking in the class*." Additional concerns included unprofessional instructor behaviour, lack of engagement, irrelevant content, heavy workload, and technology issues. As one student summarised, "*These unfair set of expectations left students extremely stressed and did not foster a welcoming learning environment*." Another commented, "*This course was poorly managed. It was more stressful and did not add to my learning*." Interpreted through CLT, these reports reflect instructional factors aligned with increased extraneous load.

Table II: Mapping students' learning experiences to elements of cognitive load theory

Themes	Categories	Codes	Frequency
Elements increasing extraneous load for students (N=400)	Poor instructional quality	Ineffective teaching, poor teaching, unclear guidance, inconsistent learning objectives, teaching method confusion, fast paced or rushed delivery, unprepared, no guidance, need improvement in sharing materials, poor slides, bad slides, slides unorganised	152
	Poor course organisation and management	Poor design, conflicting materials, design problem, disorganised, unorganised, unorganised delivery, poor organisation, confused-unprepared, poor course management	57
	Content overload	Content overload, overloaded materials, overload and rushed	52
	Assessment issues	Insufficient assessment, inappropriate assessment, poor assessment, unfair assessments, poor assessment planning	45
	Communication issues	Poor communication, bad communication, lack of communication, language barrier, difficulty understanding, hard to understand	25
	Unprofessional instructors	Lack of professionalism, behaviour issues, rude behaviour, dismissive behaviour, attitude and professionalism, lack of empathy	20
	Lack of student engagement	Lack of engagement or interactions, minimal class interactions, extraneous talking, unclear course objectives	15
	Unrelated or Irrelevant content	Unrelated course content, irrelevant assignments, relevance issues	15
	Workload management	Workload, schedule changed, inconvenience, unsupportive.	14
	Learning environment	Poor learning environment, poor environment	5
Elements reducing extraneous load (N=321)	Great personal attributes of professors	Amazing professor, best professor, caring professor, great professor, good teacher, approachable and flexible, knowledgeable, knowledgeable & caring, knowledgeable & passionate, experienced, humble and caring	168
	Effective teaching style	Effective teaching, excellent teaching. organised teaching. great teaching, enjoyable teaching, engaging teaching, energetic & focused, positive learning experience, excellent delivery	100
	Enjoyable learning experience	enjoyable learning, enjoyable learning environment, positive attitude, positive feedback, helping students, positive learning experience, great environment	36
	Organised course materials	Organised, organised and focused, great materials, excellent slides and materials, slides organised, great course organisation, great content and materials	17

Themes	Categories	Codes	Frequency
Elements minimising intrinsic load (N=67)	Simplify complex content presentation	Everything was easy to follow, interdisciplinary approach bridges the gap between theory and application, incorporating cases/scenarios in the lectures, presented it in a manner that was understandable, emphasise main points, clarify difficult concepts, examples and lot of practice questions to understand the concept, easy to understand, explain details, elaborates on topic, focus main concept	58
	Instilling interest using real-life examples	bring real life experience into the class, making the class very interesting	9
Elements increasing germane load (N=20)	Engaging and interactive learning experience	Engaging, interactive, focused, increased attention, enjoyable learning, inclusive learning environment, positive learning environment, understand better, energy and enthusiasm	15
	Helpful materials and instructions	Clear homework or worksheet, understand everything thoroughly	3
	Constructive feedback	Constructive feedback	2

In contrast, 321 codes highlighted practices that students perceived as supportive and well-structured. Personal attributes of faculty (168 mentions)—described as caring, approachable, knowledgeable, and passionate—were frequently praised for creating a positive environment. For example, one student wrote, "*Not only does she demonstrate a deep understanding of the subject matter, but her approach to teaching is both engaging and effective. I thoroughly enjoyed her class and found her to be an excellent educator. Her commitment to students' learning and her professionalism are truly commendable*." Effective teaching style (100 mentions) also emerged as a key factor, with students valuing clear explanations, organisation, and engaging methods. One noted, "*Professor is very organised and uses the most effective study methods to help incorporate student interaction in the classroom*." Another shared, "*She offers excellent PowerPoints with all the information that is needed by her students. She explained the topics extremely well. She goes above and beyond explanation during her lecture*." These elements were interpreted as factors that reduce extraneous load by easing unnecessary cognitive strain.

A smaller set of 67 codes emphasised faculty efforts to make challenging material more accessible. Students valued clear explanations, practice problems, and real-life examples that clarified difficult concepts. For instance, one student commented, "[*Professor*] *really gave an impressive breakdown of calculations' skills that ease and clarify the concepts*." Another wrote, "*[Professor] stands out as one of the best professors I've had. Despite teaching one of the challenging subjects, her well-structured and detailed slide presentations make the material much easier to understand*." Real-world illustrations were also praised: "*[Professor] does a great job teaching this course. He explains everything very well and always gives examples from real life professional situations at different pharmacy settings*." Interpreted through CLT, these practices represent strategies that help manage intrinsic load.

Finally, 20 codes described instructional practices that students associated with active and meaningful learning. These included interactive teaching, constructive feedback, inclusive environments, and opportunities for collaboration. For example, students reported that "*The course material was presented in a very organised manner, which helped me follow along and understand better*" and "*His teaching methods encouraged active student participation in activities and discussions*." Others highlighted the value of scaffolding and group activities: "*Group assignments offer a welcome relief, allowing us to redirect our focus towards the course material itself*." Another noted, "*He makes the class very interactive, and an inclusive learning environment to ask questions and be more involved*." These patterns were interpreted as practices that can foster germane load by supporting deeper engagement and schema construction.

Discussion

This study analysed students' FCE comments on their learning experiences and interpreted them through the lens of CLT. While students did not directly reference CLT, their feedback was aligned with its constructs to provide insights into intrinsic, extraneous, and germane cognitive load. Most student experiences were coded under the theme of increasing extraneous load, with subsequent coding capturing elements that reduced extraneous load, minimised intrinsic load, and promoted germane load.

In the current study, most student experiences coded to increased extraneous load reflected perceptions of poor instructional quality, including ineffective teaching, inconsistent objectives, unclear guidance, disorganised delivery, conflicting materials, and content overload. Collectively, these issues contributed to a stressful and unwelcoming learning environment, often compounded by perceptions of unfair expectations and poor course management that further detracted from learning. The student experiences coded to this theme align with earlier studies demonstrating how instructional inefficiencies and poor course organisation contribute to increased extraneous load (Jordan *et al.,* 2020; Sweller *et al.,* 2019). Moreover, research has shown that extraneous cognitive load is amplified also by interpersonal distractions from instructors and peers (Frisby *et al.,* 2018; Myers *et al.,* 2015). Such interruptions hinder learning by diverting attention away from essential content and obstructing the processes necessary for schema construction (Van Merrienboer & Sweller, 2005; Frisby *et al.,* 2018).

Conversely, students' positive experiences, interpreted by the authors as indicators of reduced extraneous load, represented the second most common theme. Positive feedback highlighted approachable, knowledgeable, and supportive professors, along with clear explanations and organised materials; these were categorised as elements reducing extraneous load. Drawing from recent literature, various instructional approaches have been proposed and validated to balance and control cognitive load (Sweller & Van Merrienboer, 2013; Paas & Sweller, 2014). The present study findings align with studies showing that a supportive and structured instructional approach enhances cognitive capacity by reducing unnecessary burdens (Feldon *et al.,* 2019; Fisher & Frey, 2021). Reducing extraneous cognitive load by limiting distractions, streamlining lecture materials, and refining instructional delivery enables students to concentrate on essential content without unnecessary cognitive burden (Jordan *et al.,* 2020). When learning environments are free from disruptions, students can more effectively sustain attention, integrate information, and construct schemas, which in turn enhances overall learning outcomes (Choi *et al.,* 2014; Rajesh & Reena, 2015). Additionally, instructional clarity is essential in reducing cognitive strain and ensuring students can easily grasp and retain new information(Bolkan & Goodboy, 2020; Martin & Evans, 2019).

Building on these student experiences, it is important to consider specific instructional strategies that can help minimise extraneous cognitive load. To manage extraneous cognitive load, instructors should provide clear and concise instructions while maintaining a consistent structure and format throughout the lesson (Cowan, 2010; Van Merriënboer & Sweller, 2010; Qiao *et al.,* 2014; Van Merriënboer & Kirschner, 2017). Sequencing content logically minimises unnecessary strain and supports knowledge building (Van Merriënboer & Kirschner, 2017). Well-designed presentation materials—such as simplified slides with limited text, bullet points, relevant visuals, and periodic summaries—help students focus on essential content (Clark, 2008; Costley *et. al.,* 2024). Reducing redundancy, integrating information across modalities, and optimising delivery further lessen extraneous load (Jordan *et al.,* 2020). Instructor performance also plays a critical role: clear speech, confident presence, purposeful eye contact, and controlled gestures sustain attention while minimising nonverbal distractions enhances learning. Effective use of multimedia and a well-prepared lecture environment further engage students and reduce disruptions (Jordan *et al.,* 2020; Khuman, 2024).

Beyond extraneous load, student comments were coded to factors related to intrinsic load, reflecting how the inherent complexity of course content and the instructional approaches shaped their ability to engage and learn effectively. In health profession education, basic and clinical science courses are inherently complex and impose a high intrinsic cognitive load (Van Merriënboer & Sweller, 2010). In this study, faculty practices such as clear explanations, real-life examples, interdisciplinary approaches, and practice questions were coded to the theme of minimising intrinsic load. Students especially valued efforts to clarify difficult concepts and apply real-life pharmacy scenarios, which enhanced engagement and connected coursework to authentic practice. Recognising the limits of working memory, educators can apply CLT principles to design effective strategies that help students master these demanding subjects. Current literature on cognitive load theory provides insights into instructional techniques that support effective learning and knowledge retention by managing intrinsic load (Siregar, 2024; Van Merriënboer & Sweller, 2010). Strategies include breaking down complex concepts into smaller components (Gooding *et al.,* 2017), using step-by-step tutorials that progress from simple to complex tasks (Cutting & Saks, 2012), and limiting the number of elements introduced at once through isolated, interactive components to avoid overwhelming cognitive demands (Leppink & Duvivier, 2016; Sweller, 2010).

Germane cognitive load is the mental effort directed toward constructing and automating schemas, which are mental structures that organise and integrateknowledge (Paas *et al.,* 2004; Moreno & Park, 2010). Schema construction involves processes such as organisation, interpretation, classification, inference, and differentiation (Mayer, 2002). In this study, fewer student comments were aligned with germane load, though interactive and engaging strategies, constructive feedback, and well-structured materials were noted as supportive. Literature highlights approaches that enhance germane load by directing learners' attention to essential processes, including active learning, case studies, contextualised examples, and self-explanation (Catrambone & Yuasa, 2006; Gerjets *et al.,* 2006; Papadopoulos *et al.,* 2009; Costley & Lange, 2018). Chunking, scaffolded , peer teaching, reflection and collaborative activities reinforce schema construction (Ten Cate & Durning, 2007; Demetriadis *et al.,* 2008; Kirschner *et al.,* 2009; Costley, 2021). Visual tools and real-world applications further promote integration, comprehension, and long-term retention (Cook, 2006; Kolfschoten & Brazier, 2013; Schindler & Burkholder Jr, 2014; Woo, 2014; Sweller *et al.,* 2019; Kassam *et al.,* 2024; Greenberg & Zheng, 2023; Zhong, 2024).

At AUHS School of Pharmacy, FCEs are triangulated with other assessment measures—including learning outcomes mapping, embedded assessments, curriculum reviews, and AACP surveys—so that student feedback is interpreted within multiple evidence streams. Applying a CLT lens to these comments has provided faculty with clearer insight into how their teaching practices influence intrinsic, extraneous, and germane load. These insights have been incorporated into faculty workshops to foster reflective practice and guide strategies that minimise cognitive overload and enhance student learning. Over the past four years, this approach has contributed to tangible curricular reforms, including credit-hour realignment, content streamlining to reduce overload, and the introduction of practice-readiness and licensure preparation courses (Islam & Yang, 2023).

Table III presents a framework of best teaching practices grounded in CLT, outlining strategies to manage intrinsic load, reduce extraneous load, and enhance germane load. Mapping student evaluations to CLT constructs provides a feasible strategy to detect when instructional design may inadvertently increase extraneous load (e.g., disorganised delivery, unclear expectations, excessive content density, rapid pacing). Conversely, identifying comments aligned with germane load helps educators recognise when students are engaging in deeper schema construction. Embedding CLT-informed coding into routine course review can therefore function as an early warning system—highlighting instructional practices that compromise learning efficiency while reinforcing those that promote effective learning.

Table III: Best teaching practice recommendations informed by CLT

Optimisations area (CLT elements)	Recommended teaching practices
Managing intrinsic load	• Break down complex topics into smaller, sequentially organized components. • Introduce foundational knowledge before advancing to complex concepts. • Use scaffolding techniques such as worked examples and guided practice. • Relate new information to students' prior knowledge to reduce complexity. • Gradually increase task complexity as learners build expertise.
Reducing extraneous load	• Provide clear, concise instructions and maintain consistent course structure. • Avoid redundant or irrelevant information that may distract learners. • Simplify presentation slides by using minimal text and clear visuals. • Use signaling (highlighting, bolding, arrows) to direct learners' attention to key elements. • Ensure alignment between objectives, activities, and assessments. • Eliminate unnecessary jargon or overly complex wording.
Enhancing germane load	• Encourage active learning strategies such as group discussions, problem-solving, and case studies. • Incorporate retrieval practice, self-explanations, and reflection activities. • Provide constructive feedback that promotes schema development. • Use real-world examples and contextualized cases to foster deeper understanding. • Promote metacognitive strategies, including planning, monitoring, and evaluating learning. • Foster a positive learning environment that supports motivation and engagement.
Overall integration	• Balance intrinsic, extraneous, and germane load to match learners' cognitive capacity.
	• Regularly assess student feedback to adjust teaching strategies.
	• Incorporate multimodal instruction (visual, auditory, kinesthetic) to enhance comprehension.
	• Design learning activities that progressively build expertise while avoiding overload.

This study has several limitations. First, the data were collected from a single institution, which may not capture the diversity of institutional cultures, student demographics, and instructional methods across different settings. Additionally, the reliance on self-reported FCE data introduces inherent subjectivity. The study period also spans the COVID-19 era, during which shifts in instructional modality, assessment practices, and student stressors may have influenced the tone and content of evaluations. Although three investigators independently coded using an a priori CLT-informed codebook, no formal inter-rater reliability statistics were calculated; consensus was instead reached through discussion, which enhances trustworthiness but limits reproducibility. Because the same students often evaluated multiple courses, repeated measures may have influenced code frequencies, meaning results should be interpreted as descriptive patterns rather than independent observations. Finally, the analysis does not provide a direct measure of cognitive load but interprets student perceptions through the lens of CLT constructs, serving as an applied theoretical framework rather than a validated instrument. Despite these limitations, the dataset offers unique longitudinal insights into student learning experiences in an accelerated PharmD programme and highlights opportunities for future studies to integrate perception-based analyses with validated CLT measures and more diverse institutional contexts.

Conclusion

This study emphasises the connection between students' perceived learning experiences and CLT, offering suggestions to improve faculty teaching practices. In healthcare education, where the volume and complexity of information are particularly high, educators can create more effective and meaningful learning experiences by applying CLT principles. By identifying strategies that effectively reduce extraneous load and enhance germane load, educators can optimise teaching practices and create more supportive learning environments. The model provides a replicable framework for other pharmacy programmes seeking to align student perceptions with evidence-based educational enhancement.

Conflict of interest

The authors declare no conflict of interest.

Source of funding

The authors did not receive any funding.

References

Baddeley, A. (2012). Working memory: Theories, models, and controversies. *Annual review of psychology*, **63**(1), 1–29. https://doi.org/10.1146/annurev-psych-120710-100422

Baddeley, A. D., & Hitch, G. (1974). Working Memory. In G. H. Bower (Ed.), *Psychology of learning and motivation* (Vol. 8, pp. 47-89). Academic Press.

Bolkan, S., & Goodboy, A. K. (2020). Instruction, example order, and student learning: Reducing extraneous cognitive load by providing structure for elaborated examples. *Communication Education*, **69**(3), 300–316. https://doi.org/10.1080/03634523.2019.1701196

Camina, E., & Güell, F. (2017). The neuroanatomical, neurophysiological and psychological basis of memory: Current models and their origins. *Frontiers in Pharmacology*, **8**, 438. https://doi.org/10.3389/fphar.2017.00438

Catrambone, R., & Yuasa, M. (2006). Acquisition of procedures: The effects of example elaborations and active learning exercises. *Learning and Instruction*, **16**(2), 139–153. https://doi.org/10.1016/j.learninstruc.2006.02.002

Choi, H.-H., Van Merriënboer, J. J., & Paas, F. (2014). Effects of the physical environment on cognitive load and learning: Towards a new model of cognitive load. *Educational Psychology Review*, **26**, 225–244. https://doi.org/10.1007/s10648-014-9262-6

Clark, J. (2008). PowerPoint and pedagogy: Maintaining student interest in university lectures. *College Teaching*, **56**(1), 39–44. https://doi.org/10.3200/CTCH.56.1.39-46

Cook, M. P. (2006). Visual representations in science education: The influence of prior knowledge and cognitive load theory on instructional design principles. *Science Education*, **90**(6), 1073–1091. https://doi.org/10.1002/sce.20164

Costley, J. (2021). How role-taking in a group-work setting affects the relationship between the amount of collaboration and germane cognitive load. *International Journal of Educational Technology in Higher Education,* **18**(1), 24. https://doi.org/10.1186/s41239-021-00259-w

Costley, J., Gorbunova, A., Courtney, M., Chen, O., & Lange, C. (2024). Problem-solving support and instructional sequence: impact on cognitive load and student performance. *European Journal of Psychology of Education,* **39**(3), 1817–1840. https://doi.org/10.1007/s10212-023-00757-7

Costley, J., & Lange, C. (2018). The moderating effects of group work on the relationship between motivation and cognitive load. *International Review of Research in Open and Distributed Learning*, **19**(1). https://doi.org/10.19173/irrodl.v19i1.3325

Cowan, N. (2010). The magical mystery four: How is working memory capacity limited, and why? *Current Directions in Psychological Science*, **19**(1), 51–57. https://doi.org/10.1177/0963721409359277

Cutting, M. F., & Saks, N. S. (2012). Twelve tips for utilising principles of learning to support medical education. *Medical Teacher*, **34**(1), 20–24. https://doi.org/10.3109/0142159X.2011.558143

Demetriadis, S. N., Papadopoulos, P. M., Stamelos, I. G., & Fischer, F. (2008). The effect of scaffolding students' context-generating cognitive activity in technology-enhanced case-based learning. *Computers & Education,* **51**(2), 939–954. https://doi.org/10.1016/j.compedu.2007.09.012

Eggen, P. (2020). Information processing and human memory. *Oxford Research Encyclopedia of Education*. https://oxfordre.com/education/view/10.1093/acrefore/9780190264093.001.0001/acrefore-9780190264093-e-86

Feldon, D. F., Callan, G., Juth, S., & Jeong, S. (2019). Cognitive load as motivational cost. *Educational Psychology Review*, **31**, 319–337.

Fisher, D., & Frey, N. (2021). Better learning through structured teaching: A framework for the gradual release of responsibility. ASCD Publication. https://files.ascd.org/staticfiles/ascd/pdf/siteASCD/publications/books/Better-Learning-Through-Structured-Teaching-3ed-sample-chapters.pdf

Frisby, B. N., Sexton, B. T., Buckner, M. M., Beck, A.-C., & Kaufmann, R. (2018). Peers and instructors as sources of distraction from a cognitive load perspective. *International Journal for the Scholarship of Teaching and Learning*, **12**(2), 6. https://digitalcommons.georgiasouthern.edu/cgi/viewcontent.cgi?article=1790&context=ij-sotl

Galanes, G. J., & Carmack, H. J. (2013). "He's really setting an example": Student contributions to the learning environment. *Communication Studies*, **64**(1), 49–65. https://doi.org/10.1080/10510974.2012.731464

Gerjets, P., Scheiter, K., & Catrambone, R. (2006). Can learning from molar and modular worked examples be enhanced by providing instructional explanations and prompting self-explanations? *Learning and Instruction*, **16**(2), 104–121. https://doi.org/10.1016/j.learninstruc.2006.02.007

Ghanbari, S., Haghani, F., Barekatain, M., & Jamali, A. (2020). A systematised review of cognitive load theory in health sciences education and a perspective from cognitive neuroscience. *Journal of Education and Health Promotion,* **9**. https://doi.org/10.4103/jehp.jehp_643_19

Gooding, H., Mann, K., & Armstrong, E. (2017). Twelve tips for applying the science of learning to health professions education. *Medical Teacher*, **39**(1), 26–31. https://doi.org/10.1080/0142159X.2016.1231913

Greenberg, K., & Zheng, R. (2023). Revisiting the debate on germane cognitive load versus germane resources. *Journal of Cognitive Psychology*, **35**(3), 295–314. https://doi.org/10.1080/20445911.2022.2159416

Hadie, S. N., Manan, H. A., Ismail, Z. I. M., Talip, S., & Rahim, A. F. A. (2018). Creating an engaging and stimulating anatomy lecture environment using the Cognitive Load Theory-based Lecture Model: Students' experiences. *Journal of Taibah University Medical Sciences*, **13**(2), 162–172. https://doi.org/10.1016/j.jtumed.2017.11.001

Islam, M. A., & Yang, Y. (2023). Establishing a culture of assessment in a new U.S. pharmacy school: Lessons learned. *Health Professions Education*, **9**(4), Article 6. https://hpe.researchcommons.org/journal/vol9/iss4/6

Jordan, J., Wagner, J., Manthey, D. E., Wolff, M., Santen, S., & Cico, S. J. (2020). Optimising lectures from a cognitive load perspective. *AEM Education and Training*, **4**(3), 306–312. https://doi.org/10.1002/aet2.10389

Kalyuga, S. (2011). Cognitive load theory: How many types of load does it really need? *Educational Psychology Review*, **23**, 1–19. https://doi.org/10.1007/s10648-010-9150-7

Kassam, A., de Vries, I., Zabar, S., Durning, S. J., Holmboe, E., Hodges, B., . . ., & Kalet, A. (2024). The next era of assessment within medical education: Exploring intersections of context and implementation. *Perspectives on Medical Education*, **13**(1), 496. https://doi.org/10.1007/s10648-010-9150-710.5334/pme.1128

Kawaguchi-Suzuki, M., Blakely, M. L., Childs-Kean, L. M., Devraj, R., Frenzel, J. E., Medina, M. S., . . . Franks, A. M. (2023). Guidance for qualitative research manuscripts in pharmacy education. *American Journal of Pharmaceutical Education*, **87**(7), 100089. https://doi.org/10.1016/j.ajpe.2023.10008 9

Khuman, P. (2024). The impact of non-verbal communication in teaching: Enhancing educational effectiveness. A Global Journal of Humanities, **7**, 89. https://www.gapbodhitaru.org/res/articles/(89-95)%20THE%20IMPACT%20OF%20NON-VERBAL%20COMMUNICATION%20IN%20TEACHING%20ENHANCING%20EDUCATIONAL%20EFFECTIVENESS.pdf

Kirschner, F., Paas, F., & Kirschner, P. A. (2009). A cognitive load approach to collaborative learning: United brains for complex tasks. *Educational Psychology Review*, **21**, 31–42. https://doi.org/10.1007/s10648-008-9095-2

Kolfschoten, G. L., & Brazier, F. M. (2013). Cognitive load in collaboration: Convergence. *Group Decision and Negotiation*, **22**, 975–996. https://doi.org/10.1007/s10726-012-9322-6

Leppink, J., & Duvivier, R. (2016). Twelve tips for medical curriculum design from a cognitive load theory perspective. *Medical Teacher*, **38**(7), 669–674. https://doi.org/10.3109/0142159X.2015.1132829

Leppink, J., Paas, F., Van der Vleuten, C. P., Van Gog, T., & Van Merriënboer, J. J. (2013). Development of an instrument for measuring different types of cognitive load. *Behavior Research Methods*, **45**, 1058–1072. https://doi.org/10.3758/s13428-013-0334-1

Leppink, J., & van den Heuvel, A. (2015). The evolution of cognitive load theory and its application to medical education. *Perspectives on Medical Education*, **4**, 119–127. https://doi.org/10.1007/s40037-015-0192-x

Loftus, G. R., & Loftus, E. F. (2019). *Human memory: The processing of information*. Psychology Press.

MacPhail, C., Khoza, N., Abler, L., & Ranganathan, M. (2016). Process guidelines for establishing intercoder reliability in qualitative studies. *Qualitative Research*, **16**(2), 198–212. https://doi.org/10.1177/1468794115577012

Martin, A. J., & Evans, P. (2019*). Load reduction instruction (LRI): 14Sequencing explicit instruction and guided discovery to enhance students' motivation, engagement, learning, and achievement Advances in Cognitive Load Theory* (pp. 15-29). Routledge.

Mayer, R. E. (2002). Rote versus meaningful learning. *Theory into Practice*, **41**(4), 226–232. https://doi.org/10.1207/s15430421tip4104_4

Moreno, R. (Ed.). (2010). Cognitive load theory: Historical development and relation to other theories. In J. L. Plass, R. Moreno, & R. Brünken (Eds.), *Cognitive load theory* (pp. 9–28). Cambridge University Press. https://doi.org/10.1017/CBO9780511844744.003

Myers, S. A., Goldman, Z. W., Ball, H., Carton, S. T., Atkinson, J., Tindage, M. F., & Anderson, A. O. (2015). Assessing college student use of anti-citizenship classroom behavior: Types, reasons, and association with learning outcomes. *Communication Teacher*, **29**(4), 234–251. https://doi.org/10.1080/17404622.2015.1064984

Olmos-Vega, F. M., Stalmeijer, R. E., Varpio, L., & Kahlke, R. (2023). A practical guide to reflexivity in qualitative research: AMEE Guide No. 149. *Medical Teacher*, **45**(3), 241–251. https://doi.org/10.1080/0142159X.2022.2057287

Ouwehand, K., Lespiau, F., Tricot, A., & Paas, F. (2025). Cognitive Load Theory: Emerging trends and innovations. *Education Sciences*, **15**(4), 458. https://doi.org/10.3390/educsci15040458

Paas, F., & Ayres, P. (2014). Cognitive load theory: A broader view on the role of memory in learning and education. *Educational Psychology Review*, **26**, 191–195. https://psycnet.apa.org/doi/10.1007/s10648-014-9263-5

Paas, F., Renkl, A., & Sweller, J. (2004). Cognitive load theory: Instructional implications of the interaction between information structures and cognitive architecture. Instructional science, 32, 1-8. https://doi.org/10.1023/B:TRUC.0000021806.17516.d0

Paas, F., & Sweller, J. (2014). In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 27–42). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.004

Papadopoulos, P. M., Demetriadis, S. N., Stamelos, I. G., & Tsoukalas, I. A. (2009). Prompting students' context-generating cognitive activity in ill-structured domains: Does the prompting mode affect learning? *Educational Technology Research and Development*, **57**, 193–210. https://psycnet.apa.org/doi/10.1007/s11423-008-9105-6

Pollock, E., Chandler, P., & Sweller, J. (2002). Assimilating complex information. *Learning and instruction*, **12**(1), 61–86. https://psycnet.apa.org/doi/10.1016/S0959-4752(01)00016-0

Qiao, Y. Q., Shen, J., Liang, X., Ding, S., Chen, F. Y., Shao, L., . . . Ran, Z. H. (2014). Using cognitive theory to facilitate medical education. *BMC Medical Education*, **14**, 79. https://doi.org/10.1186/1472-6920-14-79

Rajesh, R., & Reena, M. (2015). A review on worksystem interactions in a technology enabled class room. *International Journal of Technology Enhanced Learning*, **7**(2), 99–115. https://doi.org/10.1504/IJTEL.2015.072026

Schindler, L., & Burkholder Jr, G. J. (2014). Instructional design and facilitation approaches that promote critical thinking in asynchronous online discussions: A review of the literature. *Higher Learning Research Communications*, **4**(4), 11–29. https://files.eric.ed.gov/fulltext/EJ1133209.pdf

Siregar, T. (2024). Differentiated instruction from the perspective of Cognitive Load Theory. https://www.researchgate.net/publication/383001031_Differentiated_Instruction_from_the_Perspective_of_Cognitive_Load_Theory

Sweller, J. (2010). Element interactivity and intrinsic, extraneous, and germane cognitive load. *Educational Psychology Review*, **22**, 123–138. https://doi.org/10.1007/s10648-010-9128-5

Sweller, J., Ayres, P., Kalyuga, S. (2011). The expertise reversal effect. In: *Cognitive Load Theory. Explorations in the Learning Sciences, Instructional Systems and Performance Technologies*, vol 1. Springer, New York. https://doi.org/10.1007/978-1-4419-8126-4_12

Sweller, J., & Van Merrienboer, J. J. (2013). Instructional design for medical education. In Kieran Walsh (ed.), *Oxford Textbook of Medical Education*. Oxford Academic. https://doi.org/10.1093/med/9780199652679.003.0007

Sweller, J., Van Merrienboer, J. J., & Paas, F. (2019). Cognitive architecture and instructional design: 20 years later. *Educational Psychology Review*, **31**, 261–292. https://doi.org/10.1023/A:1022193728205

Sweller, J., Van Merrienboer, J. J., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, **10**, 251–296. https://doi.org/10.1023/A:1022193728205

Ten Cate, O., & Durning, S. (2007). Peer teaching in medical education: twelve reasons to move from theory to practice. *Medical teacher*, **29**(6), 591–599. https://doi.org/10.1080/01421590701606799

Tyng, C. M., Amin, H. U., Saad, M. N., & Malik, A. S. (2017). The influences of emotion on learning and memory. *Frontiers in Psychology*, **8**, 235933. https://doi.org/10.3389/fpsyg.2017.01454

Van Merrienboer, J. J., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review*, **17**, 147–177. https://doi.org/10.1007/s10648-005-3951-0

Van Merriënboer, J. J., & Sweller, J. (2010). Cognitive load theory in health professional education: design principles and strategies. *Medical education*, **44**(1), 85–93. https://doi.org/10.1111/j.1365-2923.2009.03498.x

Van Merriënboer, J. J., & Kirschner, P. A. (2017). *Ten steps to complex learning: A systematic approach to four-component instructional design*. Routledge.

Wang, S., Tripathy, S. P., & Öğmen, H. (2022). Capacity and allocation across sensory and short-term Memories. *Vision*, **6**(1), 15. https://doi.org/10.3390/vision6010015

Widmaier, E., Raff, H., & Strang, K. T. (2022). *Vander's human physiology*. McGraw-Hill US Higher Ed USE.

Woo, J.-C. (2014). Digital game-based learning supports student motivation, cognitive success, and performance outcomes. Journal of Educational Technology & Society, **17**(3), 291–307. https://www.jstor.org/stable/jeductechsoci.17.3.291

Young, J. Q., Van Merrienboer, J., Durning, S., & Ten Cate, O. (2014). Cognitive load theory: Implications for medical education: AMEE Guide No. 86. *Medical teacher*, **36**(5), 371–384. https://doi.org/10.3109/0142159X.2014.889290

Zhong, L. (2024). Investigating learning efficiency and mental efficiency in a personalised role-playing-game environment. *Interactive Learning Environments*, **32**(6), 2713–2724. https://doi.org/10.1080/10494820.2022.2157840