RESEARCH ARTICLE

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Examining the Impact of Teachers' Cognitive Load on Student Engagement and Learning Outcomes in Saudi Classrooms

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Abstract:

Background: Examining the influence of cognitive load on teacher strategies, engagement of students, and the learning experience as a whole is essential in an age of educational reform and rapid technological evolution in instruction to become more effective pedagogues and positively impact student learning outcomes. This study explicates the experience of cognitive load on teachers and their ability to teach and engage students in the Saudi Arabian 21st-century classroom.

Methods: The study employed a qualitative research design to investigate the experiences of the 35 Saudi teachers through an essential initiative stratum of how they were selected in a randomized stratified process to ensure as much diversity as possible in the teaching community throughout Saudi Arabia. Data was collected through open-ended questionnaires and analyzed using thematic analysis to ascertain primary patterns and themes emerging from the data.

Results: The analysis found that (1) cognitive load significantly impacted teachers' choice of instructional strategies. (2) Classroom performance was also impeded due to cognitive load as teachers struggled to engage and manage the learning of the students inside the classroom; (3) systemic and environmental forces devolving curriculum and integration of technology into instruction increased cognitive demand for the teachers, and (4) teachers employed various adaptive practices to manage their cognitive demands. They demonstrated tremendous resilience and adaptability in their practice.

Conclusion: The study findings have practical implications for educational policy and practice, primarily that educational policy and practice should focus on providing specific assistance and professional learning for teachers managing cognitive load. Finally, based on the findings, the study's limitations and recommendations for further research are discussed.

Keywords: Cognitive load, Educational reforms, Saudi Arabian education, Saudi school teachers, Student engagement, Instructions.

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1. INTRODUCTION

In this fast-evolving sphere, with digital infusion on the leading edge of trailblazing changes in education in the Kingdom, cognitive load comes to the fore as a deciding factor in or even a driver of educational triumph [1]. Dealing with the mental effort involved in processing information and the performance of tasks, cognitive load

theory derived from the nature of working memory and the limits of its capacity for processing information is particularly germane to education [2]. However, this study makes a novel departure by interrogating the subtle dimensions of teachers' cognitive load, which implicate their students' engagement and learning dynamics. This critical space remains largely under-explored, particularly within the nuances of the Saudi education paradigm. This study pivots on the realization that Saudi teachers are navigating an infrastructural transition in education that is growing ever more complex; they are called upon to carry through fundamental reforms from new curricula to state-of-the-art learning tools, and their cognitive burdens are acute [3]. These emanate from coping with novel pedagogies and managing the varying needs of learners, which can potentially stretch their professional effectiveness and the resonance of the engagement quality. The interrelation between teachers' cognitive load and its commensurate repercussions for educational outcomes warrants a concentrated probe, particularly in the particular pedagogic destinies and dilemmas of the Kingdom.

The overarching aim of this study was to examine and elucidate the impact of teachers' cognitive load on student engagement and learning within the unique milieu of the Saudi educational system. It moved beyond generic claims, breaking down specific instantiations of cognitive load in the Saudi educational context for a granular understanding of how such phenomena shape teaching practices and student interactions. It was the rigour in laying out strategies teachers can employ to mitigate cognitive load that is crucial for improving the quality of education needed to succeed amidst ongoing educational reforms in Saudi Arabia. The overarching aim of this study was to examine and elucidate the impact of teachers' cognitive load on student engagement and learning within the unique milieu of the Saudi educational system. The following questions were put under the lens in light of this main research objective.

(1) In what specific ways does teachers' cognitive load manifest in their pedagogical approaches and engagement with students within the Saudi Arabian educational context?

(2) Through what lived experiences do teachers in Saudi Arabia articulate the impact of their cognitive load on the academic performance and engagement of their students?

(3) Which factors inherent to the Saudi educational scene are perceived to modulate the influence of teachers' cognitive load on their pedagogical effectiveness and students' educational experiences?

2. LITERATURE REVIEW

2.1. Theoretical Foundations of Cognitive Load Theory

Cognitive Load Theory (CLT) was coined by John Sweller in the late 1980s and is founded on the premise that the capacity of working memory significantly influences learning [4]. In its simplest form, CLT posits that if learning is to be effective, instructional materials must be designed so that learning is consistent with human cognitive architecture. CLT has identified three types of cognitive load--intrinsic, extraneous, and germane--each impacting the processing and retention of information differently [5]. Intrinsic cognitive load relates to the complexity of the learning material, which is influenced by the intrinsic structure of the content and the knowledge possessed by the learner. It is considered to be a constant throughout the learning process, as learning focuses on presenting the information without introducing or increasing extraneous or unnecessary elements that may overload working memory; however, the goal is to simplify the presentation of the content without unnecessarily reducing the essential complexity required for the content to make sense [6].

On the other hand, extraneous cognitive load results from instructional design and how information is presented to learners. This load is not inherent to the material being learned; it comes from how it is taught [7]. Instructional materials that are poorly designed and fail to align with the cognitive structures of the human mind can load unnecessary information onto the learner's working memory, creating a problem with learning. It has been established that a well-formed instructional design is essential for reducing extraneous cognitive load to enhance learning efficiency [8]. Germane cognitive load is the intellectual effort required to process, understand and integrate new information within long-term memory. In other words, germane cognitive load reflects the cognitive resources devoted to managing the learning process. The instructional strategies that facilitate schema construction and automatization result in a higher germane load and more profound learning outcomes [9].

At the heart of CLT is the construct of working memory and its limitations in terms of being able to learn effectively. Techniques for reducing extraneous cognitive load serve to conserve cognitive resources so that learners can process new information in ways that enhance schema construction [10]. Schemas help people make sense of information, organize it, and create associations that facilitate better and more efficient recall. One of the most critical insights from CLT is that instructional designs should reduce extraneous load by design, manage intrinsic load through careful scaffolding and differentiation, and optimize germane load through strategies designed to promote more significant activity on the part of the learner and create opportunities for the construction and refinement of schemas [7-11]. Put into practice — and there is every reason to believe these principles will lead to much more engaging and effective learning, allowing students to process, understand, and remember new information more efficiently.

2.2. Impact of Cognitive Load on Teaching Effectiveness

In educational psychology, a fundamental question concerns the relationship between cognitive load and

teaching effectiveness. A direct link resides between teachers' cognitive load and their ability to facilitate effective learning [12]. This is because cognitive load plays an equally critical role in shaping teachers' instructional capacities and outcomes despite its common association with student learning. This comprises an intricate relationship where teachers must modulate their cognitive resources for optimal instructional delivery, student engagement, and classroom management [13].

Educators operating in educational contexts face an intrinsic cognitive load when dealing with the complex curriculum content they must teach [10]. The depth of the subject matter shapes this cognitive load and the pedagogical skill level required to depict it effectively. Teachers struggle to simplify complex ideas into broken-down pieces for their students, ensuring this does not compromise the material's depth or rigour. This forces educators to match their information structuring to their students' cognitive architecture to preserve and effectively depict core concepts within their academic discipline [14].

Extraneous cognitive load for teachers arises from non-instructional sources, such as how educational material is organized and presented [15]. Much of this is beyond the control of schools and teachers. This includes the continuing barrage of administrative tasks and clunky tech integration that has either nothing to do with teaching or is the direct result of not allowing teachers the appropriate space required to learn how to deploy educational technology in a way that is beneficial for teaching and learning, and the always-overlapping, often ambiguous, and too frequently changing assortment of standards to which teachers are told to teach [16]. It is also an issue because, ideally, this is mental bandwidth that can help enrich teacher practices and student engagement [17].

In contrast, germane cognitive load refers to the deliberate cognitive effort teachers invest in activities that directly support the refinement of their instructional techniques and learning environment [8]. This includes creating innovative lesson plans, adopting reflective teaching practices, and participating in professional development activities that expand their pedagogical toolkit. Unlike instructional strategies that target intrinsic and extraneous cognitive load, those that heighten germane cognitive load should figure critically in the quest to cultivate teaching effectiveness, as they support the deep processing of instructional strategies and the development of teaching methods [18, 19].

The sweet spot wherein each type of cognitive load is balanced is central to the quest for maximal teaching effectiveness [20]; perpetually managing intrinsic and extraneous cognitive load is a recipe for teacher burnout [21], which can leave little cognitive capacity available to teachers who might otherwise be preparing to mount engaging and dynamic learning opportunities [8]. As a result, purposive and systematic efforts to support teachers in their efforts to offload extraneous load and elevate germane load need to be foregrounded in educational systems and policies [22] direct measures might include simplifying administrative processes, the evidence-informed infusion of technology into instruction, and the cultivation of professional learning cultures that celebrate innovation and eschew a culture of critique by ensuring that reflective practice is a norm and not an ideal to which one merely pays lip service [16]. Ultimately, the story of how cognitive load shapes teaching effectiveness reflects the need for educational design to attend to teachers' cognitive constraints and the directed supports that can be extended to optimize their instructional capacity.

2.3. Teacher's Cognitive Load and Student Engagement

Several interconnected themes emerge from previous literature that will help explore the relationship between teachers' cognitive load and how this influences student engagement and learning. The cognitive demands teachers' experience, whether in delivering curriculum, managing classrooms, or integrating new pedagogical technologies, are integral in shaping their instructional practices and, in turn, students' learning experiences [7, 9, 23]. A heavy cognitive load can severely limit teachers' ability to implement various teaching methods, including innovative forms of instruction. Indeed, feeling overwhelmed by the complex demands of the profession has been noted as a potential reason teachers may choose more traditional, lecture-based styles of instruction [24]. This shift, in turn, reduces the variety of student's learning experiences and may lead to disengagement as active, participatory learning experiences become rare. These issues are particularly pronounced within the swiftly changing Saudi education system, where new reforms and technology integration have become increasingly common [13, 25, 26],

The Saudi educational sphere is characterized by its ambitious reforms and commitment to integrating digital technologies in the classroom [27]. These create unique challenges for teachers, which may augment teachers' cognitive load [27]. Navigating new pedagogical approaches, mastering educational technologies, and aligning their teaching with ever-evolving national standards are complex and cognitively effortful tasks. They emphasize the need for research within the Saudi context that identifies the unique factors related to teachers' cognitive load and the subsequent impacts of this on student engagement and learning outcomes [13, 25]. Skulmowski and Xu [7] argue that a more holistic approach is required to mitigate the adverse effects of high cognitive load for teachers. This would involve combining professional development, expert support in curriculum planning, and external technological assistance. In so doing, enabling teachers with these resources and knowledge can help them overcome and mitigate their overall cognitive load [9]. This is particularly germane considering the ongoing reform in Saudi Arabia to transform their classrooms by encouraging innovation, creativity and the elevation of overall education quality. Resilient support will assist

teachers in managing their cognitive load, amplify their capacity to engage students productively and facilitate quality educational experiences [13]. There is substantial cause to inspect further the nexus between teachers' cognitive load and student engagement and learning in the Saudi environment. Disentangling how the cognitive pressures on teachers cascade through teaching practices and into the broader educational outcomes that ensue holds significant promise for developing the constraints and affordances of the Saudi educational milieu. At its essence, this is about the requirement to help educators manage their cognitive load in ways that will enhance student engagement and learning achievement.

2.4. Factors Affecting Cognitive Load in Saudi Education

The up-to-date scene of Saudi Arabia's educational system fluctuates with noteworthy reforms such as Vision 2030. However, teachers face many challenges affecting their cognitive load, educational effectiveness, and student engagement [12]. The push for educational modernization means an entirely new curriculum, requiring teachers to immediately reconcile a pedagogical tradition that does not emphasize critical thinking or problem-solving to one based entirely upon them [28]. This requires a complete reimagining of their tried-and-true tactics, which constitutes a sizeable cognitive burden as they not only retool their practice but embark upon new educational models that are complicated and polysemantic [13]. At the same time, the inclusion of digital technologies in the classroom, another primary driver behind Saudi educational reform, adds yet another cognitive layer [29]. Not only do teachers now need to be facile with several e-learning platforms, but a myriad of digital tools have been fast-tracked in a move towards online education that has been necessitated by a global pandemic [30], requiring both proficiency and engagement strategies in a new virtual modality [31].

Linguistic complexity also complicates the delivery of STEM content. English, which is typically a non-native language for both Saudi teachers and students [32], carries a substantial cognitive load, requiring educators to translate complex concepts into a language that they and their students may not fully command, further escalating cognitive demands for teachers as they shepherd students' understanding of and engagement with these content areas [33]. Although some regions in the nation have experienced robust professional development opportunities to support their educators in this transition, others have not, leaving teachers in these jurisdictions with the increased burden of cognitive demands in their roles [25]. Additionally, administrative and policy demands stretch teachers' cognitive resources further. In this climate of high-stakes testing, accountability metrics, and administrative minutiae, teachers have less mental bandwidth for planning instruction and building connections with students. Moreover, the time and mental energy required to document and participate in school-wide initiatives further depletes teachers' cognitive capacity [34, 35]. The

trials ahead demand a clear understanding of existing demands on teachers and targeted intervention strategies to reduce cognitive loads.

2.5. Research Gap

Research has examined the CLT through several pedagogical lenses [36], in real-world problem-solving scenarios [37], as regards motivation and engagement [17-22], to critique existing theories [19], in the introduction to new learning paradigms [38], and a great deal more.

Ginns *et al*. [22], for instance, investigate the benefits of practice-related activities in learning and improving problem-solving skills without the adverse effects of increasing cognitive load. The effect of reducing the cognitive load in virtual and real models is examined by Khalil *et al*. [38], who suggested it resulted in an increased understanding and augmented memory of the anatomy model, which remains critical for understanding physiological and medical science. According to Berssanette and de Francisco [36], in their recently published review of cognitive load theory on cyber learning and learning technology integration, the demand for learning to program highlights the critical role of cognitive load theory in digital learning environments. Leppink's [34] recent work suggested that the cognitive theory of cognitive information processing or schema acquisition, automation, and transfer as procedures for optimizing cognitive load is a challenge for educators seeking to apply cognitive load theory in practice, which she argues is regarded as the most practical tool for analyzing pedagogical materials or learning materials, in the future. Further, among these applications is the report that critically revised the germane cognitive load theory when Greenberg and Zheng [19] reinvestigated germane cognitive load, where they suggested it was time to reevaluate the multiple dimensions of cognitive load deemed germane within cognitive psychology. Blackley *et al*. [37] critique the nuances of educators' cognitive processing and decision-making in their pedagogy. The relationship between cognitive load and its effect on decision-making and behavior in educational practice has remained within, primarily, the realms of theory and critique more than empirical data. Most recently, the process of cognitive load theory application in actual practice or its theoretical limitations was found to be most challenging within the pedagogy of medicine [34].

Although these contributions significantly advance our understanding of cognitive load across various educational settings, the specific exploration of how it impacts teachers in Saudi Arabia – amid the country's extensive educational reform – and its subsequent impact on student engagement and achievement remains largely uncharted. This study seeks to explore the effects of cognitive load on teaching approaches and student achievement, intending to create specific strategies to reduce cognitive load for teachers, thereby improving educational settings in accordance with Saudi Arabia's significant educational reforms.

3. RESEARCH METHOD

3.1. Research Design

This study used a qualitative research design for its suitability in exploring teachers' perceptions, experiences, and challenges regarding the impact of teachers' cognitive load on students' engagement and academic performance. Such a design aims to yield comprehensive insights that quantitative approaches miss [39].

3.2. Participant

This study included 35 participants of different ages from different educational disciplines within the Saudi context. In qualitative research, it is well-known that depth and richness of data are more essential than a larger sample size. Therefore, the selection of 35 participants falls well within the ideal range required to achieve data saturation [40]. The participants were selected using a stratified sampling method to ensure a balanced representation of teaching majors. Stratification was based on teaching levels (primary, secondary, and tertiary), teaching experience (novice: 1–5 years, mid-career: 6–15 years, experienced: 16$^+$ years), and geographical location (urban and rural). A stratified sampling method allowed for a well-adjusted selection process, where teachers were drawn randomly from each stratum to minimize selection bias and increase the

generalizability of the study across different educational levels. Participants were randomly selected within each stratum to ensure unbiased representation and diverse perspectives. Inclusion criteria required participants to have at least one year of teaching experience and current employment as educators in Saudi classrooms. Such inclusivity frames the comprehensive understanding of the nuances of cognitive load that can guide the development of targeted strategies for supporting teachers in the Saudi educational renaissance. The diversity of the sample is designated in Fig. (**1**), which outlines the sample characteristics that emerged in terms of the different subjects that the participants taught and staged aspects of their educational provision.

Fig. (**1**) delineates the demographic and professional attributes of the 35 teachers participating in the study to understand the impact of cognitive load in the Saudi educational context. The age distribution showcases a skew towards younger educators, with 42.9% falling in the 25-34 age bracket and 31.4% in the 35-44 range, suggesting the sample predominantly consists of early to mid-career teachers. This is complemented by including more experienced teachers, with 22.9% aged between 45-54 and a minimal 2.9% over 54, providing a broad perspective across generations. Teaching experience mirrors this diversity; nearly half of the participants (48.6%) possess 1-10 years of experience, blending the
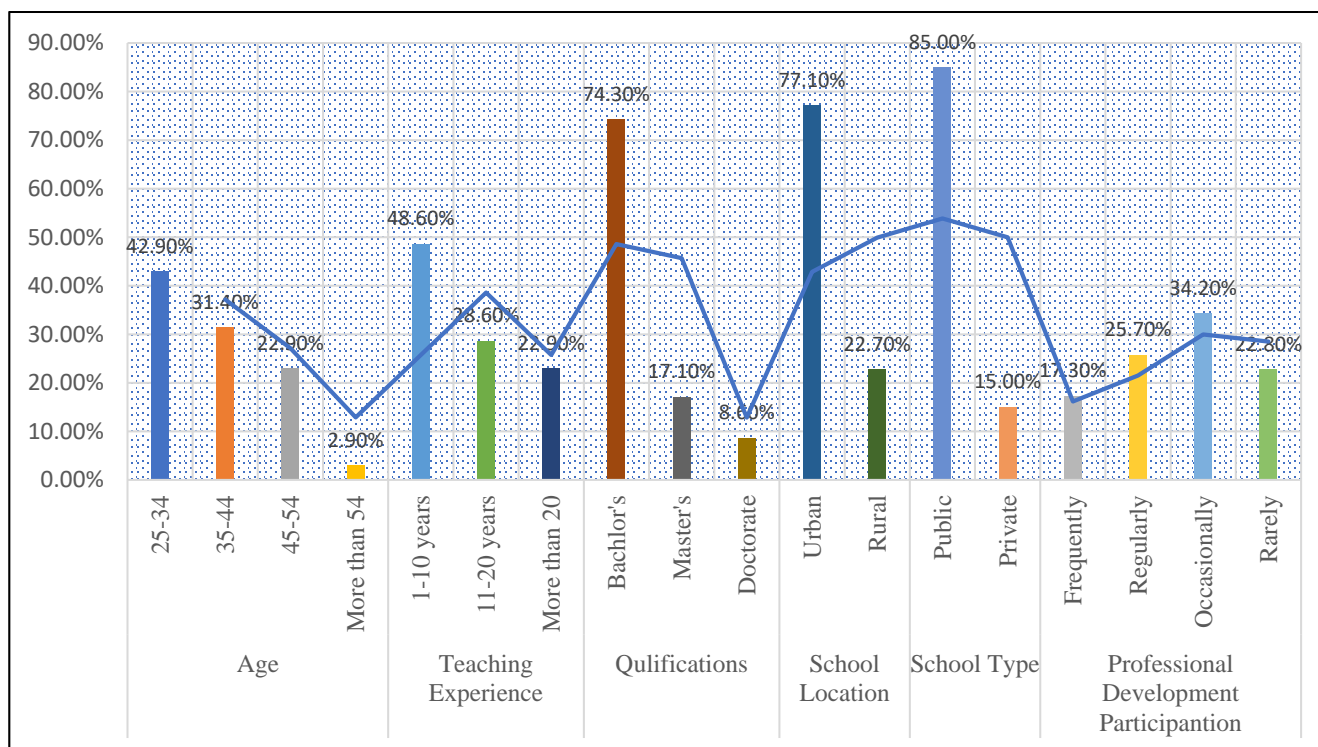

Fig. (1). Visual representation of the sample's characteristics.

insights of relatively newer teachers with those of veterans in the field, as evidenced by 28.6% having 11-20 years and 22.9% boasting over 20 years of teaching experience.

The educational qualifications of the participants primarily include Bachelor's degrees (74.3%), with a smaller fraction holding Master's (17.1%) and Doctorate degrees (8.6%), indicating a wide range of academic backgrounds. The study also reveals a significant urban bias in school locations (77.1%), with a more miniature representation from rural settings (22.9%), reflecting the general distribution of educational institutions in Saudi Arabia. A vast majority teach in public schools (85%), with private schools representing 15% of the sample. The instances of professional development participation were varied, suggesting that teachers engage in ongoing learning and training to different degrees. The frequency of the instances of professional development participation varied, with the instances of professional development participation ranging from frequent (17.3%) and regular (25.7%) to occasional (34.2%) and rare (22.8%), suggesting that the teachers varied in the opportunity and motivation for professional growth in the sample.

3.3. Instrument

The study employed primarily an open-ended questionnaire where the data was generated in order to determine how cognitive load influences teachers' instructional decisions and student engagement across time of the different reforms that have been implemented this year in Saudi Arabia. The open-ended nature of the questions is the key to reflecting educators' multi-dimensional and endowed experiences where they can qualify their experiences in great detail. This was pivotal for capturing in rich, qualitative detail how the cognitive load manifests and necessitated a nuanced approach that would likely be missed in a structured survey [41]. The questionnaire sections were divided by demographic information at the beginning and the in-depth, qualitative responses toward the end that closely followed the research questions. This procedure allowed the researcher to fully grasp the participant's context and draw out the research findings with rich contextual detail.

The first section gathered demographic data. Participants were asked to report their age, years of teaching experience, highest educational qualification, the geographical location of their school (rural/urban), the type of school (private/public), and their participation in professional development activity. This information was indispensable because it placed the ensuing findings in context and assisted the researcher's comprehension of how cognitive load and its educational stipulations can interact with teachers' diverse backgrounds and experiences. After the demographic section, the questionnaire probed the crux of the research established by the carefully crafted open-ended questions. These sought to extract the participants' descriptive narratives, permitting the elaboration of the nexus between cognitive load and a teacher's pedagogical strategies, levels of student engagement, and the educational outcomes s/he achieved in the milieu of the Saudi educational setup. The objective was to obtain first-hand accounts of dealing with cognitive load and delineating the participants' views about the broader systemic and extraneous influences that act to exacerbate or ameliorate these difficulties. For a detailed exposition of the demographic parameters covered and the specific open-ended questions posed, please refer to Appendix **1**.

3.4. Instrument Validity

The open-ended questionnaire employed in this study underwent content validity scrutiny over an elaborate procedure of expert reviews and pilot testing. It was first scrutinized hierarchically by a panel of three educational and cognitive psychology experts. The panel checked whether the questionnaire adequately embraced the main themes of the study and cross-verified that each point of the questionnaire adequately reflected the targeted research domains. The insights acquired from this panel led to laying down levels of revisiting and iterative modifications required to adapt the more conventional questionnaire that more precisely accorded to the focus of the study. Subsequent to this, a pilot testing round involved a small set of five teachers matched to the demographic distribution characteristics of the primary study population. This was crucial in determining the pragmatic aspects of the questionnaire–clarity of questions, relevance of questions in the teachers' contexts and the effectiveness of the response elicitation. The values-based valuable feedback from this pilot round was the last stage that readied the questionnaire for soliciting comprehensive and significant insights into the intricate expression of the cognitive load and its impact across educational practices and student engagement in the crucial Saudi Arabian landscape.

3.5. Data Collection

The data collection phase, which spanned a month and a half, took place during the second half of the academic year 2023–2024; after rigorous validation, the re-articulated open-ended questionnaire was deployed *via* Google Forms to a teacher cohort that had been predetermined, leveraging its user-friendly interface and broad accessibility, contributing to a large number of participants from teachers residing in different geographical areas with various nationalities and serving in diverse institutional settings across Saudi Arabia. They were briefed on the research's aim and pledged confidentiality to ensure complete transparency and genuine introspective answers. Furthermore, participants were provided with a concise and standardized definition of cognitive load, including its three dimensions - intrinsic, extraneous, and germane cognitive load. Practical examples relevant to teaching contexts were also included to ensure a consistent understanding of the concept among all participants, facilitating meaningful and focused responses to the questionnaire. The schedule and the online mode were deliberately planned to fit a promptly and dedicatedly designed instructional program to fit the

academic calendar to maximize participation rates and minimize their interference with the subjects' ongoing commitments.

3.6. Data Analysis

The data collected from the open-ended questionnaires for this study were subjected to a detailed thematic analysis. This methodological approach was explicitly chosen given its robustness for identifying and interpreting patterns within qualitative data [42]. The analysis process began with an immersive reading of all responses, manifest and latent alike, to form a deep and exhaustive understanding of the data collected. This was a critical step, as it facilitated the preliminary coding process, during which key translated insights relevant to cognitive load, teaching practices, and student experiences and learning were systematically elicited. Thematic analysis followed Braun and Clarke's (2006) six-step framework: (1) familiarization with the data by repeatedly reading the responses, (2) generating initial codes by systematically coding significant features of the data, (3) identifying themes by collating codes into broader patterns, (4) reviewing themes to ensure alignment with the dataset, (5) defining and naming themes to capture the essence of each, and (6) producing the final report. This laborious coding process allowed for the data set to be broken down into an array of potential emergent themes that reflected the core research inquiry in the context of the Saudi educational system. To enhance rigour, themes were validated through peer debriefing and iterative review to ensure credibility and consistency in interpretation. These emergent themes were scrutinized for appropriateness to the coded data and the strategic aims of the broader research. The emergent themes solidified through rigorous review and refinement into more clearly defined and named themes. This final thematic structure provided a deep, organized vantage point for the teachers' experiences and perspectives to uncover the interplay between cognitive load and its impact on educational practices and outcomes.

3.7. Ethical Considerations

This study adhered to ethical standards, and its objectives were clearly outlined on the first page of the survey to ensure that participants were fully informed about its focus. Their continuation to the questionnaire was taken as proof of informed consent, as a consequence implying their voluntary participation, indicating that they understood the purpose of the research and their participation in it.

4. RESULTS

4.1. Theme one: Cognitive Load in Educational Strategies and Learner Engagement

Teachers agree that adapting instructional practices to manage cognitive load is critical. How teachers adapt their practices affects what they choose for engagement and pedagogy. The shift comes from realizing that they must ensure the content is covered methodically and keep the

environment and learning accessible and engaging. One teacher shared: "*Given the difficulty of topics, I have found breaking down information into more minor, more digestible parts essential, especially when my cognitive load is high. This helps manage my workload and ensures students continue to be involved and can follow along without feeling overawed.*"

Clearly, educators see the cognitive load/engagement relationship, realizing that student engagement is supported, in large part, by how nimbly teachers dance around their cognitive hurdles. As one experienced instructor acknowledges about a particularly tough class, "*When my cognitive load is high, so is the quality of my engagement in the classroom; what this means is that I can be less present with lighter loads, and this results in lower student engagement and a less dynamic classroom atmosphere.*" Another instructor, who often partakes in professional development, adds — in an observation that shows a kind of mastery many aspire to, "*Balancing my cognitive load is essential to creating an environment that ignites students' passion for learning.*" Sharing insights at the level of a master, they are also pointing to a critical relationship: the cognitive load underpinning an educational engagement that demands the careful lifting of teacher impact and student effort.

The responses further make clear an additional strategy of adopting active [v. passive] instructional practices [*e.g.*, problem-solving and discussion *vs.* rote exercise and learning of discrete bits] to avoid disengagement and cognitive overload. As it turns out, teachers opt for interactive, student-centered strategies that lower the cognitive load as they support learning the basics. One of the teachers, with a doctoral degree, describes this: "*Utilizing group work and interactive discussion has been a game changer. I can disperse the cognitive load while ensuring students are engaged and are processing the material versus passively receiving it.*" One more said: "*Getting creative with the use of technology has also given me the ability to decrease my cognitive load, making lessons more engaging and interactive for students.*" These statements and others reflect a sense of engagement in instruction that delivers more student activity and engagement in some way. They speak to the capacity of adaptive teaching strategies—and teachers.

Teachers also noted the importance of recognizing and responding to students' cognitive loads, which may vary among individuals. They recognized the variety of cognitive loads that are "*out there*" and that "*teaching that is wise requires sensitivity to the variety of student cognitive loads and ways they handle information.*" One teacher observed that "*where students are concerned, it is possible to be too rich or too thin in cognitive loads.*" A reflective observation highlighted the need to be flexible with teaching: "*Recognizing the signs of cognitive overload in my students prompts me to adjust my teaching on the fly. Sometimes, it means pausing the planned curriculum to revisit concepts or introduce alternative explanations until I see signs of comprehension and renewed engagement.*"

Consequently, this theme qualitative analysis reveals how teachers are actively shaping their cognitive load through adaptive teaching strategies to construct an environment that is both engaging and important for learning. It is with the intention that teachers are revealing that carefully balancing the cognitive load on not only themselves but, equally importantly, on their students is a strategic teaching orchestration. A recollection of this is, "*Adapting my teaching strategies to manage my cognitive load not only aids my well-being but significantly enhances the learning experience for my students.*" Encompassing the decisions and actions where, the cognitive load is not a barrier to learning but rather a vehicle that results in, and is tantamount to, a well-orchestrated dance.

4.2. Theme Two: Experiential Insights on Cognitive Load and Educational Achievement

It is apparent that mastering the art of managing cognitive load is a skill that comes with experience, and this is couched in numerous strategies designed to help teachers balance the workload of teaching with the many moving parts of engagement. Findings included the observation that "*With experience comes the ability to manage my cognitive load better. Older teachers generally shared more strategies for managing workload and classroom engagement.*" One teacher noted, "*With years under my belt, I have learned the importance of pacing and prioritization to manage my cognitive load, directly impacting my students' learning positively.*"

The degree to which a teacher is educated in the field also impacts their approach to cognitive load, with most secondary teachers who hold higher degrees referencing more proven strategies to mitigate its negative toll. For example, a teacher with a Master's degree shared, "*My advanced studies introduced me to various pedagogical theories that I apply to minimize cognitive overload for both myself and my students, enhancing our classroom's overall academic achievement.*"

The context of the school's location and the type of school in which a teacher works also play a significant role in shaping their experiences of cognitive load. In such scenarios, teachers from urban and public schools were more likely to equate the sheer size of classes and the diversity of student needs with higher cognitive load. Flexibility to pitch a lesson one way or another to maintain effective teaching and engagement was likelier to be front-and-center in their recollections. Another teacher from an urban public school discussed these challenges: "*The multiplicity and size of my class challenge me to find advanced ways to manage my cognitive load while ensuring each student remains engaged and performs academically.*"

Simply doing what comes naturally or is comfortable will often result in cognitive overload. Regular participation in professional development became a common factor that enabled teachers to manage cognitive load more effectively, and able teachers were much more likely to articulate sophisticated strategies for doing so.

One said, "*Attending workshops on mindfulness and pedagogical strategies has been crucial in managing my cognitive load, allowing me to foster a more engaged and successful learning environment for my students.*"

4.3. Theme Three: Systemic and Environmental Determinants Affecting Cognitive Load in the Saudi Educational Sphere

Teachers described that systemic changes impacted their cognitive loads differently at the various career stages. The younger professionals, who tended to be more facile with digital tools, were nonetheless taxed by the pace at which new curricula were mandated. A young teacher in his early thirties described, "*Despite my comfort with technology, the rapid curriculum changes demand continuous adaptation, significantly increasing my cognitive load and making it challenging to maintain the same level of student engagement.*" While this theme was consistent across the different age groups, the coping strategies were more varied and linked to experience.

Teachers with higher qualifications frequently mention their ability to harness their research and analytical talents to satisfy the ever-evolving teaching requirements. For instance, a Doctorate-level educator discussed, "*Drawing from the in-depth academic background associated with a PhD...Despite all this, the extent of changes still raises my cognitive workload appreciatively.*" Similarly, a teacher with a Master's degree explained, "*If anything, the ability to research enables me to make my way through updates in the curriculum and technology systematically...However, navigating those elements without overloading overall cognitive load is a significant challenge.*" These quotes illustrate the Herculean feat necessary just to adjust to one new technology or shift in the curriculum; they emphasize that these cognitive load limitations are ever-present, even for the most educated instructors.

Rural and public school teachers also saw school location and type implications for cognitive load challenges. A rural public school teacher noted, "*A lack of resources and many students contribute heavily to my cognitive load and make it more difficult to incorporate new teaching strategies, as required by educational reforms.*" Similarly, a rural school teacher noticed, "*Some rurality and nearly nonexistent professional development opportunities add to the cognitive loads that I bear as I try to keep up with pedagogical innovations.*" These comments highlight teachers' unique challenges in less privileged schools and the urgent need to develop support infrastructures for reducing cognitive load and advancing equitable educational practices.

The importance of professional development in ameliorating cognitive load emerged as a critical consideration, as more active participants felt capable of managing systemic changes. "*Engaging in continuous professional development has been critical for managing my cognitive load. Learning new pedagogical techniques helps me navigate educational reforms more effectively, enhancing my teaching practice,*" noted a teacher who frequently attended workshops.

5. DISCUSSION

The analysis yields a critical finding in response to the first research question about how teachers' cognitive load translates to their pedagogical practices in engaging students within the Saudi Arabian educational context. Teachers' cognitive load is shown to have profound implications for their selection of pedagogical approaches, as well as their student engagement in the classroom. Teachers consistently discussed transforming their pedagogical strategies to accommodate their cognitive load, accepting less-compound instructional processes to reduce their cognitive burden. However, this adaptive response of simplifying– albeit in pursuit of maintaining teaching effectiveness – simultaneously modifies the depth and pace of students' interaction and engagement with the curriculum.

These findings are rooted in some underlying dynamics. The swift pace of change in educational reforms and integration of new technologies into the Saudi educational system appears to compound teachers' cognitive load and compel them to adopt less-compound teaching approaches. This reduction in cognitive load has the dual benefit of making instruction more manageable for the teacher and ensuring that dense or rapid instructional pacing does not overwhelm students, conforming to sound pedagogical practices designed to enrich student understanding and engagement. Moreover, resource and support inequities across various educational settings may further contribute to teachers' cognitive strain, influencing their pedagogical selection and strategies for engaging students.

These findings are further supported by longstanding research that clearly articulates the connection between cognitive load and its salience in teaching and learning. For example, the seminal work of Sweller [15] on CLT explicates the debilitating effects of high cognitive load on information retention and problem-solving, which can be extended to understand teachers' pedagogical selection as synonymous with cognitive strain. Further, research from Paas *et al*. [14] illuminates the necessity for optimizing cognitive load to teach and learn effectively – providing substantiation to the teachers' choice in this analysis to simplify instruction as a practical means of managing workload. The role of professional development in conferring strategies to manage cognitive load, as evidenced in the analysis, maps on to recommendations from Darling-Hammond *et al*. [18] that underscore continual training as essential to building teachers' cognitive adequacy.

Turning to the second research question concerning how educators in Saudi Arabia describe the impact of their cognitive load on students' academic performance and engagement, the findings illustrate a clear connection between teachers' cognitive burdens and the learning environment they shape. Most teachers relayed experiences where heightened cognitive loads impaired their ability to keep students engaged consistently and adjust instruction appropriator for optimal student engagement and performance. Consequently, this led to lower levels of student performance and classroom engagement. One teacher, echoing the vast majority, stated, "*As my cognitive load increases, my capacity for interactive and responsive teaching decreases, directly impacting students' ability to stay engaged and perform well academically.*"

The underlying explanations for these findings are multi-faceted and speak to the basic demands of the teaching profession and state-specific challenges of the Saudi educational context. The rapid and continual pace of educational reform, increased administrative duties, and demands to integrate new technologies contribute to teachers' cognitive load, thereby reducing their capacity to maintain vibrant, attentive, and flexible teaching modalities conducive to optimal student engagement and performance. As teachers navigated these obstacles, this strain on their cognitive resources inevitably materialized as diminished pedagogical efficacy and lessened student learning outcomes.

Integrating these findings with the larger academic discourse reveals alignment and marked state-specific challenges. While aligning with the findings of other researchers [25, 6] concerning the effects of cognitive overload, our work reveals that the cognitive burdens of teachers can significantly impair their level of engagement and instructional flexibility necessary to maintain high levels of student performance and engagement. This complements insights by Leppink [34] and Mutlu-Bayraktar *et al*. [35], who posit the barriers that excessive cognitive load can have on employing varied and effective teaching strategies. However, the current work extends these discussions, embedding these challenges within the unique state-specific surroundings of Saudi Arabia, as shown by de Bruin *et al*. [5] and many others. As we see from the earlier analysis, Saudi Arabia's state of swift educational reforms and technological innovations amplified the challenges of cognitive load, demonstrating both the need for tailored supports and, importantly, ongoing teacher training critical in helping educators not just navigate but also to help them exploit cognitive pressures in a manner that can foster an environment that is congruent with effective teaching and student learning experiences against the ever-changing backdrop of the Saudi educational sector.

Considering the third research question, the Saudi educational ecosystem includes a unique set of factors that shape how teachers' cognitive load influences their pedagogical effectiveness and students' learning experiences. This analysis demonstrates that the need to regulate increasingly cognitive-heavy practices results from the intersections of systemic influences that regulate the pace of curriculum reforms, that privilege technological fluency, and that take the form of resource disparities, and environmental influences such as the pressures produced by standardized assessments, all of which together configure a cognitive landscape for educators. In response to this landscape, one participant wrote, "*Navigating the swift currents of educational*

reform and the steep climb toward technological fluency greatly saps my cognitive resources, straining my ability to maintain effective teaching practices."

The principal goal of the Saudi educational reforms is to raise national educational standards, a bold ambition that gives rise to this interpretation. The well-intentioned reforms generate substantial cognitive strain, requiring continuous adaptation and skill enhancement on the part of the teachers. Given the differential degree of support and resources across the educational determinants, teachers are most likely placed in vastly divergent positions regarding their cognitive load to manage and their capacity to engage students productively. As identified by a teacher, "*The disparity in resource availability and administrative backing in our educational system adds a layer of cognitive burden, limiting our engagement capabilities and the application of innovative pedagogies.*"

Correlating these findings to extant literature reveals that the links between educational reform efforts and teacher cognitive load are well theorized. For instance, scholarship by Darling-Hammond *et al.* [18] highlights the critical importance of offering comprehensive support to teachers amidst educational transitions, suggesting that such support functions to "*decrease the cognitive load*" and heighten the quality of teaching. In a related study on integrating technology in education, Ertmer and Ottenbreit-Leftwich asserted that although technological tools can "*enhance learning*," the absence of preparation and support for teachers amplifies cognitive load, thereby lessening pedagogical quality.

6. IMPLICATIONS

Considerable theoretical and practical implications arise from the main findings of this study. Theoretically, this research enriches the cognitive load theory, clarifying how the cognitive load manifests in teachers' lived experiences within the dynamic context of Saudi Arabia's educational reforms and technology adoption. It broadens the cognitive load theory to encompass the situated experiences of teachers in which the theory may influence teaching effectiveness and student engagement. Furthermore, it underscores the broader relevance of cognitive load theory in diverse educational contexts, inviting a re-evaluation of the framework to incorporate external factors such as technology-related challenges and cultural reforms. It speaks to the broader relevance of cognitive load theory in educational contexts. It invites a re-evaluation of cognitive load theory to argue for a more comprehensive framework that includes factors [such as technology-related challenges and cultural reform] beyond the individual psychological determinants of teacher cognitive load. These theoretical advancements could pave the way for research into optimized educational practice that strives to reduce the cognitive burden on educators and improve the quality of education more broadly.

In practical terms, the findings offer critical implications for educational policy, school administration, and teaching practices in Saudi Arabia and for educational systems worldwide facing similar challenges of reform and technological integration. The study highlights the need for thoughtfully designed professional development programs that equip teachers with the skills to navigate cognitive challenges effectively. These programs should address core competencies, including managing technological demands and adapting to ongoing reforms while fostering a supportive teaching environment. Adequate resources and administrative backing are essential to alleviate cognitive strain and promote teacher well-being. For educational policymakers, the findings emphasize the importance of carefully sequenced implementation of reforms, informed by teacher feedback, to ensure their feasibility and cognitive manageability. This approach ensures that reforms achieve their intended outcomes and sustain teachers' capacity to engage students effectively.

7. LIMITATIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

It is essential to recognize the current study's limitations and suggest directions for future research. The study should mainly focus on using a secondary qualitative data source. It also utilized only a small Saudi sample and did not include observed cognitive load ratings of participants as a supplement to self-report. There are numerous opportunities for future researchers to enhance the depth and robustness of the study's findings by including additional data from classroom observations, interviews with students in addition to teachers, and a more comprehensive array of quantitative data. These kinds of inquiries would be consistent with the advantages of a mixed-methods approach. Future research could also investigate a broader cross-section of Saudi educators. Attempting to generalize the findings to a broader and more diverse educator population could be a practical next step. A second way is to utilize longitudinal study designs to uncover the dynamic ways teachers' cognitive load changes, especially within the context of continual educational reforms. Third, researchers could conduct comparative studies across different educational contexts or cultures to understand how cognitive load is managed differently.

CONCLUSION

This study examines how cognitive load affects school teachers in Saudi Arabia. It investigates how cognitive load impacts teaching approaches, student participation and the broader educational context. The findings from the qualitative analysis of data collected have demonstrated how cognitive load has a direct effect on the teacher's ability to use a dynamic approach to teaching and maintain student interest and how environmental and systemic factors, such as changes to the curriculum and the integration of technology, can exacerbate these challenges. The research also demonstrates the resilience and flexibility of teachers in dealing with these complexities and how they employ various strategies to mitigate these ramifications. The paper argues that they must be supported by a rich educational ecosystem that recognizes and accommodates the cognitive load placed

on the role of the teacher. It recommends that future research in similar areas adopt mixed-methods approaches and increased participant diversity to ensure findings are more generalizable and in-depth. The research provides valuable insights into how the cognitive load on teachers might be reduced to help them be more effective teachers and ideally effect more prosperous student outcomes in Saudi Arabia and potentially similar educational contexts worldwide.

AUTHORS' CONTRIBUTION

A.A.A.: Data collection; R.F.A: Draft manuscript. All authors reviewed the results and approved the final version of the manuscript.

ABBREVIATION

CLT = Cognitive Load Theory

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the Committee for Research Ethics at Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudia Arabia (No. 1138).

HUMAN AND ANIMAL RIGHTS

All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all participants.

STANDARDS OF REPORTING

COREQ guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The qualitative data supporting the findings of this article includes interview transcripts and thematic analysis. Due to privacy and confidentiality considerations, the data is not publicly available but can be accessed upon reasonable request from the corresponding author [R.A].

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

APPENDIX 1

Dear Participants,
I welcome your participation in my research study "Examining the Impact of Teachers' Cognitive Load on Student Engagement and Learning Outcomes in Saudi Classrooms." This study explores the relationship between teachers' cognitive load, teaching methodologies, and the resultant effects on student engagement and learning outcomes. As a teacher, your insights and experiences are invaluable in understanding this dynamic. Your responses will contribute significantly to a deeper understanding of the challenges and strategies related to cognitive load in the educational sphere. Please rest assured that all information you provide will be treated with the utmost confidentiality and used solely for research purposes. The questionnaire should take approximately [30 minutes] to complete. I sincerely appreciate your willingness to share your experiences and perspectives. Your participation is not just a contribution to this study but a valuable addition to the broader educational discourse.
Thank you for your time and valuable input.

Part 1: Demographic Information				
Age:	25-34	35-44	45- 54	More than 54
Teaching Experience:	1-10	11-20		More than 20
Qualifications:	Bachelor's	Master's		Doctorate
School Location:	Urban	Rural		
School Type:	Public	Private		
Professional Development Participation:	Frequently [more than 4 times per year]	Regularly [3-4 times per year]	Occasionally [1-2 times per year]	Rarely [less than once a year]

Part 2: Questionnaire's Questions	
Question 1	Describe how cognitive load affects your choice of teaching strategies and instructional methods in a typical classroom setting.
Question 2	How do you perceive the relationship between your cognitive load and the level of student engagement during lessons?
Question 3	Share a specific experience where your cognitive load directly impacted a student's academic performance.
Question 4	Reflect on an incident where cognitive load challenges influenced your approach to student engagement. What were the outcomes?
Question 5	Identify and discuss any systemic or environmental factors within the Saudi educational context that exacerbate or alleviate your cognitive load.

Question 6	How do these factors, identified in the previous question, specifically impact your teaching effectiveness and the educational outcomes of your students?

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