

Research Article

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Enhancing Translation Pedagogy: Exploring Learners' Cognitive Loads Using Contextual Instruction

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Abstract

Background: Effective translation practice requires a profound understanding of source and target languages. Previous research acknowledges the role of context in translation, but few explore this through analysis of cognitive load translations.

Purpose: This study aims to address a gap in educational research by investigating how contextual instruction and translation procedures affect learners' cognitive loads during translation activities. Utilizing eye-tracking technology aims to provide insight into cognitive processes and inform teaching techniques.

Method: This study employs a quasi-experimental approach, with ten individuals divided into control and experimental groups. Eye-tracking methodology tracks and reveals cognitive processes that occur during translation, enabling analysis of learners' decision-making and cognitive loads. The data was analyzed using one-way ANOVA descriptive analysis.

Results: It became apparent that the translators in both groups spent significant time and effort reading and translating the text, whereas context helped to restructure the translation process. The experimental group (67%) outperformed the control group (43%) in terms of cognitive burden and translation accuracy. After introducing context, both groups displayed improved outcomes, with a high rate of success (93%).

Conclusion: This research has revealed the pedagogical implications for policymakers and educators, highlighting the importance of continuous professional growth in technology use and cognitive load activities. This is critical for promoting data-driven decisions that address the particular needs of learners in various circumstances. The study concluded with recommendations for researchers and policymakers.

1. Introduction

Translation is a broad field of study that intersects with other sciences and impacts various aspects of our lives. Scholars divided this field into three main parts: source, process, and product (Kahlon & Singh, 2023). The process of creating the target text poses the greatest challenge in this field (Vermeer, 2011; Wang & Xu, 2025). The translator's skills, knowledge, cultural aspects, and ideology contribute to this process of producing well-formulated text. The current study investigates how translators' knowledge influences the translation process. It sheds some light on how much time and effort it will take for the translator to complete the process, i.e., the cognitive load during the process of translation. Awajan (2023) highlights that learners can only learn what they pay attention to. At this point, he related attention to inner consciousness and its important role in activating the translator's memory in the process of translation. The present study aims to explain the role of attention in facilitating incidental vocabulary acquisition during the process of translation. Kartasheva (2021) suggests a dynamic and sometimes complex relationship between the thoughts and verbalizations of the subjects.

While Ericsson and Simon (1980) outlined the cognitive process of transferring knowledge between working memories, they propose information in a human mind is saved in two types of memories, which are classified by their capacities, whereas long-term memory (LTM) is characterized by the huge amount of data storage and the ability to retrieve it after a long period of time. Short-term memory (STM) is distinguished by its ability to store information quickly and serves as the primary tool for verbalizing human knowledge in daily life. The mental progression between these two types of memories falls under the cognitive load during challenging activities. In the context of learner translation, the cognitive load becomes an important component in determining the efficiency of translation training programs. Eye-tracking studies have indicated that novice translators have a larger cognitive burden than expert translators, especially when translating into a second language (Feng, 2017). A variety of causes, such as low language ability, unfamiliarity with the topic matter, and ineffective translation procedures, can contribute to this higher cognitive load. Furthermore, the directionality of translation, whether it is from a first language (L1) to a second language (L2) or vice versa, influences cognitive load. Thus, translating from L2 to L1 often increases cognitive load due to the added problems of language creation and the requirement for more syntactic and semantic changes (Feng, 2017).

Contextual translation tasks are key issues that determine cognitive strain. According to studies, contextual information contributes to reducing or increasing cognitive demands during translation. For example, when translators have access to contextual cues that explain ambiguous terms or phrases, their cognitive load decreases because they can make better decisions. In contrast, a lack of context might increase cognitive strain by requiring translators to invest more mental effort to resolve uncertainty. The incorporation of cognitive science into translation studies has shed insight on the complex mental processes that underpin cross-linguistic translation. An important aspect of this research is the assessment of cognitive load, which refers to the mental work necessary to grasp information during translation processes. Eye-tracking technology has developed as an effective tool in this field, providing real-time data on translators' cognitive operations. Researchers can measure the cognitive burden experienced during various translation operations by analyzing gaze patterns, fixation durations, and pupil dilation. This approach has demonstrated that contextual information reduces fixation length and regression frequency, indicating more efficient processing (Ma et al., 2021). However, the extent to which context decreases cognitive strain varies with the intricacy of the text and the translator's skill.

Recent advancements in educational technology have provided new methods to examine and measure the cognitive load involved in translation tasks (Khalaf et al., 2025). The eye-tracking technology allowed researchers to get insights into how learners allocate their cognitive resources,

resulting in a more complete knowledge of the cognitive demands placed on learners throughout translation processes. Eye-tracking technology enables researchers to observe where and how long learners focus their attention during translation activities, providing empirical data on cognitive processes. Consequently, this study tries to understand how a situation affects cognitive burdens in real time. Furthermore, it offers helpful guidance to policymakers and educators, offering potential strategies to improve teaching methodologies and enhance learning experiences. Through a context-driven approach, the study highlights how adjusting the task design can optimize cognitive load, fostering more efficient and effective learning in translation education. The study addressed three main questions:

1. Is there any relation between fixation values and translators' familiarity?
2. What are the contextual effects on fixation duration required to transfer words to working memories?
3. What is the ideal fixation duration required to identify new words?

2. Cognitive Load Theory

Sweller (1988) proposed Cognitive Load Theory (CLT), which holds the notion that human cognitive processing capacity is finite and learning is mostly effective when instructional approaches reduce superfluous cognitive load. CLT classifies cognitive burden into three categories: intrinsic, external, and relevant. Intrinsic load is the complexity of the subject being educated; extraneous load is caused by how the material is presented; and germane load is the cognitive effort allocated to learning itself (Sweller, 2011). In the case of translation students, intrinsic load is determined by the linguistic and cultural difficulties of source and target languages, but external load may result from poorly designed learning materials or insufficient technological integration. Understanding these several types of cognitive load allows educators to better support translation students in handling the mental demands of their work.

Translation students confront distinct cognitive hurdles as they process both linguistic and cultural knowledge (Hikmaharyanti et al., 2023). They must not only understand the meaning of the source material but also convey it accurately into the target language, which necessitates the constant integration of linguistic structures, idiomatic expressions, and cultural settings (Taira et al., 2021). These tasks can impose a large inherent cognitive strain on students, especially when working with unfamiliar or complex literature. According to CLT, if the instructional design fails to account for these complexities and adds an unnecessary load through inefficient teaching methods or distractions, students' cognitive resources may get overloaded, impairing their capacity to learn or translate effectively (Sweller, 2011). As a result, translation programs must carefully develop their curricula to balance task complexity with students' cognitive capacities while also including supportive elements such as context.

Recent research has explored how technology, including eye-tracking tools, can offer helpful information regarding the cognitive load of translation students. Studies using eye-tracking technology have shown that translation involves not only the decoding of text but also a complex process of attention management, where students switch between reading, recalling prior knowledge, and rephrasing sentences (Thai, 2021). Eye tracking provides an objective measure of where cognitive resources are allocated during translation tasks, allowing researchers to identify areas where cognitive load can be reduced. For example, ensuring that translation exercises provide contextual support or break down complex tasks into smaller, manageable units can help minimize extraneous load, thus enhancing learning outcomes for translation students.

Translation tasks often involve high intrinsic cognitive load due to the complexity of linguistic structures and cultural nuances, but the context in which these tasks are presented can help reduce

unnecessary cognitive strain. For instance, providing learners with contextual clues, cultural background information, or glossaries specific to the subject matter can help alleviate the mental burden of searching for meaning or dealing with unfamiliar concepts. Context-based strategies, like adjusting text difficulty to match learners' skill levels or providing guided learning experiences, help focus mental effort on key translation tasks, such as understanding and accurately conveying meaning, instead of struggling with context-related issues (Khalafa & Zinb, 2020). By recognizing the role of context in facilitating translation, educators can design learning environments that allow learners to manage their cognitive load more effectively, leading to efficient translation processes and better translation outcomes.

3. Methodology

Psychology researchers have widely used the eye-tracking method. Miller (2015) suggests that there is a clear and steady relationship between eye movement and cognitive processing. The current study used eye tracking to measure attention in second language research, considering the long history of this methodology in various fields of knowledge. Furthermore, it aims to inspect the variances between familiar or unfamiliar words and its facilitative role in the translation process. This method refers to the use of eye bubble movement to interpret cognitive processing. The study environment could be easily set using an infrared reflector on the corners of a computer and perusing eye movement on a screen. Eyes' bubble movement will be recorded with the assistance of detecting software, and then it will be analyzed later. On this scale, two key movements will be recorded. The first key movement is fixation, which refers to the location of interest and the duration of time spent on it. The second is "saccades," which refers to the quick movement of the eye's focus from one word to another.

Twelve novice translators from the translation department at the third stage of their undergraduate education are selected randomly to voluntarily participate in this study. All participants undergo a preparatory course to develop their knowledge of this methodology. Two participants were excluded because their eye movements were below 90% of the valid sample rates. Ten participants were allowed to participate in the study. The study aims to achieve valid results for attention using text containing cultural expressions. Therefore, it depended mainly on Standard English text borrowed from IELTS (International English Language Testing System) test samples. The text was obtained from an internet website (www.ielts-exam.net/docs/reading/11passage). It contains 217 words, 1314 characters and 13 sentences. The text was presented on 23-inches monitor as one unit. The reason was to preserve the translation cohesion and coherence in the target language. Also, this method will help to check whether the participants read and understand the text and which parts will represent the real challenge for them in terms of words' familiarity.

The stage of preparing participants consisted of three options for each of the chosen samples of words, and the participants had to choose one of them. The first option was "I know it," the second was "I know it, but I do not remember what it means," and the last was "I do not know it." The procedures of applying the study are based on previous designs, a pre-test of translation without context followed by immediate post-test contextual translations, as adopted by earlier scholars such as Joe (1995), McNeill (1996), Scarcella and Zimmerman (1998), etc. The word samples were chosen randomly from the text and classified in the following Table 1.

Table 1. Sample of Focus Words

Words	Characters	Reading Frequency (ms.\word)
Country	7	36197
Travelers	9	23827
Mainstay	8	66979
Agriculture	9	27446
Survey	6	772
Accommodation	14	1987
Spring up	8	11740
Catering	8	1670
Poured into	10	7680
Retail	6	89762
Manufacturing	13	8796
Billion	7	9200
Combined	8	28897
Souvenirs	9	9900
Domestic	8	8765

To have harmonised, easy, fluent experiments and limit any effects of the word's length on fixation time, both long and short words and close in characters' number of words had been selected in Table.1. The first face of the experiment is indicating the meaning of word, then in the second is the participant's translation. Because every word has a denotative and connotative meaning, participant familiarity will have the main role in identifying the proper selection for the meaning within that context. Descriptive statistical analysis of the findings is conducted using SPSS.25 software. Besides, significant differences in fixation duration between the experimental and control groups are analyzed using a one-way ANOVA test.

4. Findings

Statistical evaluation of the collected data was conducted in the initial stage before proceeding to the main data analysis stage, whereas mean score and standard deviation outcomes showed significant indications of the collected data with stable p-values less than 0.05. These findings enable proceeding to data analysis according to the punch marks proposed by Hair and Joe (2020) and Sarstedt et al. (2021). Table 2 presents the statistical indicators of the stability of the collected data for analysis.

Table 2. Normality Distributions

Tests	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
PRE_TEST	10	2.1771	.44155	-.273	.512	-.692	.992
POST_TEST	10	3.6833	.48973	-.471	.512	-.839	.992

The first research question was about the relationship between fixation value and familiarity. The pre-test revealed that the unknown words had higher fixation values than the known ones. The result emphasized the reality that higher vocabulary knowledge will require less fixation and less time to process the accurate, close meaning of these words. On the contrary, less knowledge required more fixations and more time. Technically, the total fixation duration is classified into two main parts; the first is the fixation period and the second is pass time. A detailed analysis of the eye-tracking processing of the chosen words in the pre-test is shown in Table 3.

Table 3. Words' Values of Fixation

Type	First Fixation (ms/SD)	Gaze Duration (ms/SD)	Second Pass (ms/SD)	Total Fixation (ms/SD)
Known words	258 (47.8)	363 (73.5)	302 (141.5)	350 (91.6)
Un-Known words	267 (69.7)	468 (146.4)	414 (142.8)	534 (167.3)

The findings of the study showed a vital difference between total fixation and familiarity: $T(1) = -9.122$, and $P = 000$. Also, the gaze duration is $T(7) = -6,099$, $P = 000$. The second pass time could be shown in $T(9) = -2.265$, $P = 035$. All of these findings assured the reality of total fixation. So, using a one-way ANOVA test in SPSS helps confirm important differences in how long participants focused between the experimental and control groups, as shown in Table 4.

Table 4. Statistical Analysis of Pre-Test

Group	Mean	N	Std. Deviation	Std. Error Mean
Control	1.8625	5	.34418	.10884
Experimental	2.4917	5	.27060	.08557

In addition, an analysis of translation outcomes displays significant statistical variance in translation quality and required time to perform the tasks as proposed by Hair and Joe (2020) and Sarstedt et al. (2021). Accordingly, these indicators represent main elements to identify the required effort to perform each of the tasks. Table 5 illustrates the results of the pre-test translations.

Table 5. Analysis of Pre-Test Translations

Group	Low Familiarity		High Familiarity		Average Time
	Fail	Good	Very Good	Excellent	
Control	60 %	30 %	10 %	0 %	28.06 min. ↑
Experimental	50 %	40 %	10 %	0 %	26.54 min. ↑

The second part involves analyzing the post-test results and examining how familiarity serves as a facilitative factor in the translation process. Robinson (1995) states, "Attentional mechanisms are responsible for allocating the cognitive resources that lead to noticing and encoding in memory" (p. 286). This argument emphasizes the facts announced by other scholars that a close relation between encoding known and unknown words is created between short- and long-term memories. The study shows that the process starts with reading the text and recognizing words. If the participant was familiar with the meaning of the words, the process will be illustrated in Figure 1.

**Figure 1.** Stages of Knowledge Cognitive Processing

After processing information in the post-test, the results showed significant variance from the pre-one, and the participants did better, such as ($M=23,76$ / $SD=5,43$). Findings related to the time of fixation contributed to validating two vital issues in second language acquisition. The first is that long-time fixation can help translators retrieve the data (meaning) of the word (known or unknown) from long-term memory. The second is that it can help in coding and transferring the meaning of unknown words from short-term into long-term memory.

Therefore, generalized estimating equations (GEE) for logistic regression were conducted in order to estimate further recognition rates. The GEE contributed to processing accurate data analysis for subjects under the same conditions of the study (Diggle, 2002; Ziegler, 2011). In processing GEE, each fixation, the "duration of the first fixation, gaze, the second pass, and total duration," was taken separately. To have more meaningful results, the B1 coefficient was used as a sample and test run with covariate/100. The results were multiplied by 1000 to have the outcomes of one second.

Table 6. Regression of Coefficients

First fixation duration	B1=0.189, B0=1.552 and Exp.(B)=1.208
Gaze duration	B1=0.230, B0=2.234 and Exp.(B)=1.258
Total fixation duration	B1=0.224, B0=2.345 and Exp.(B)=1.250

Table 6 shows significant effects in the first fixation processing of familiarity, Wald X2 (1) = 11.544, $P=001$, $B1 = 0.189$. The outcomes showed that (1) a second longer in the first fixation of the translator on the reading and translating process will affect recognizing and word familiarity by 10%, as shown in the pre-test to the post-one. Moreover, more significant effects were noticed in the gaze duration, with Wald X2 (1) = 21.485, $P=000$, $B1 = 0.230$. All of this evidence shows that every second of longer gaze duration by the participants in reading the text is affected by their familiarity and encoding in long-term memory 15% more than the previous one. Finally, the following equation indicates the total fixation duration is affected by word recognition and familiarity in the post-test, Wald X2 (1) = 30.603, $P=000$, $B1 = 0.224$. These findings indicated similar effects of word familiarity for translators in the translation process. The results showed that the translator's total fixation time for unknown words in the pre-test could increase its recognition in the post-one by 12% compared

to the pre-test shown in Table 7. The study noticed during the experiment that every time the text was reviewed again, the translator's recognition, familiarity, and in-coding of the unknown words improved by 6 % compared to the previous one. Table 8 displays the results of the participants' translations.

Table 7. Statistical Analyses of Post-Test

Group	Mean	N	Std. Deviation	Std. Error Mean
Control	3.9458	10	.45814	.14488
Experimental	3.4208	10	.37856	.11971

Table 8. Analysis of Pos-Test Translations

Group	Low Knowledge		High Knowledge		Average Time
	Fail	Good	Very Excellent	Good	
Control	0 %	10 %	50 %	40 %	15.03 min. ↓
Experimental	0 %	0 %	30 %	70 %	14.06 min. ↓

To conclude, the ANOVA test displayed significant differences in fixation duration between the control and experimental with a p-value (0.002). This indicator significantly influences the context in facilitating the cognitive loads of translators during the process of translation, as shown in Table 9.

Table 9. Statistical Analysis of One-Way ANOVA

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10000	1	10000	20.5	0.002
Within Groups	12200	8	1525		
Total	22200	9			

5. Discussion

The pre- and post-test results demonstrate the importance of contextual knowledge in facilitating translation tasks, particularly in reducing cognitive effort and time required. According to cognitive load theory, context is an important extraneous load reduction tool for learners, assisting them in managing the inherent cognitive demands of novel terminology. The study shows that when learners encounter unfamiliar words, fixation time, as measured by eye-tracking, plays an important role in the localization and encoding of word meanings into short-term memory, which, with repeated exposure and meaningful processing, may progress to long-term storage. However, the exact amount of fixation time required for this shift is unknown, indicating a vital subject for additional exploration. This subject is especially pertinent in translation pedagogy, as having a strong long-term vocabulary storage is critical for professional competence. Although previous research (e.g., Robinson et al., 2012; Smith, 2012) estimated fixation time at roughly 500ms, these assertions have not been empirically confirmed. The current study offers novel observations by empirically supporting the role of linguistic knowledge and experience in determining the necessary fixation time to encode unfamiliar lexical elements. Figure 2 illustrates the key components required to analyze the development of translation memory, which aligns with CLT's paradigm for regulating cognitive load to optimize learning and performance.

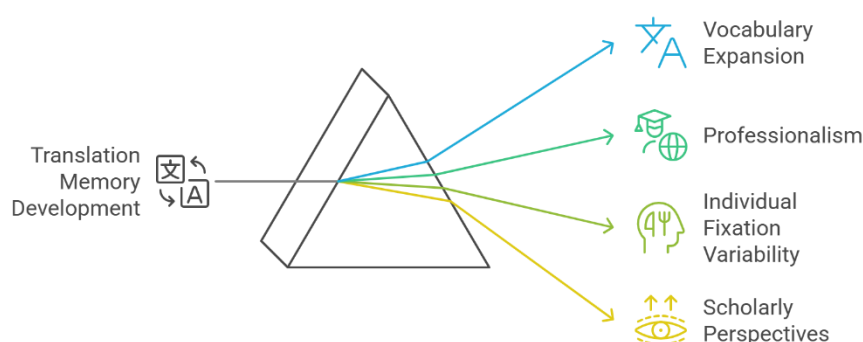


Figure 2. Fixation and Memory Development

Accordingly, the ideal duration of fixation (time) required to trigger learning new vocabularies to have a more advanced level of familiarity represents significant predictions of the total fixation (time) in the post-test from the pre-test. The effects of context are grounded in the located gap between both tests. This gap shortened, and the quality of learning amplified after (460 ms.) when the participants remembered the exact learned meaning in the post-test. In terms of translation quality, the participants achieved successful translation for the newly learned vocabularies after (410ms.). This can be related to the effects of the context in remembering a word's meaning and retrieving it from long-term memory.

This proposes a clear answer for the study's first question: that the ideal fixation duration for encoding new vocabularies into long-term memory is between 410 – 460 ms. This duration can be described as the total time and effort familiarity can preserve for a translator in every unknown word within the text during the translation process. This conclusion is in line with previous indications in the studies of Fang and Wang (2022) and Vural (2025). However, it is possible to identify how contextual knowledge will be an effective value in facilitating the translation process and developing the translator's linguistic package (vocabularies) using the eye-tracking methodology in measuring fixation values.

The findings confirmed that word's familiarity rate affects the amount of gaze fixation, second pass and total duration required for processing every word. Also, it was approved that these rates change according to the culture, behavior, level of education, experience, and many other factors that could be used for further studies. As a result of this, familiar (known) words will require less time, cognitive processing and in-coding or retrieval from long-term memory during the translation process. Unfamiliar words require more cognitive efforts. Second, the findings of the study indicate that more attention will improve encoding in long-term memory. This assumption was validated through the results presented by the pre-test and post-test participants. Whereas one second more of fixation presents a more accurate choice of meaning and successful translation. The first fixation, gaze period, and total time rates are 10%, 14%, and 12%, respectively. Furthermore, the results of repeated reading achieved 6% better translations than before.

In addition, the study shows that fixations for less than 400 ms. will not have any effects on learning gains because acquisition processing starts at this point for in-coding processing as approved by the pre-test and post-test experiment. Furthermore, some participants do not approve recognition until 500 ms. This may result from some changeable motives, such as skill, memory capacity, difficulty, or typology of the task (Robinson et al., 2012). Finally, Figure 3 shows how different important factors work together to improve learning and the quality of translation during the thinking process of translation.

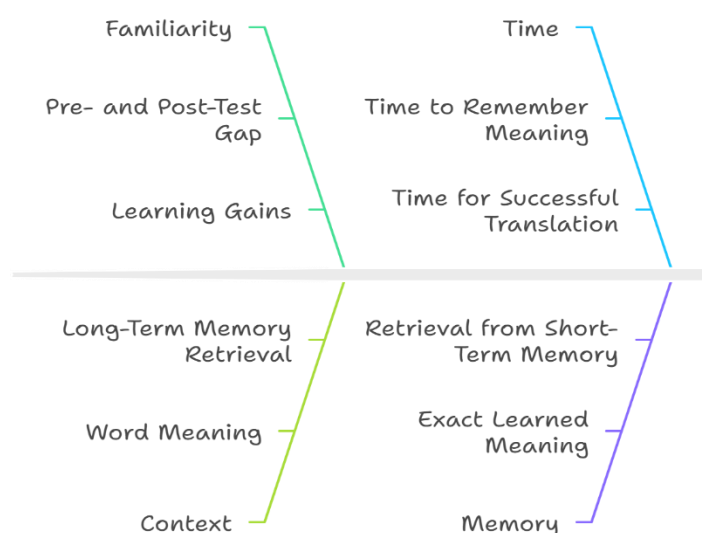


Figure 3. Factors enhancing cognitive processing.

6. Conclusion

The study examined the role of contextual knowledge in the translation process using the eye-tracking method. The study found a direct relation between fixation duration and cognitive processing of known and unknown words. This duration can affect the in-coding process of knowledge and quality of outcomes, as shown in the discussion section. This study represents empirical evidence for the idea of improving the linguistic cognitive processing of knowledge through the duration of cognitive comprehension and translators' attention. This research strengthens the relevance of knowledge understanding and processing between cognitive memories in improving knowledge acquisition and outcomes. The combination of eye-tracking technology and Cognitive Load Theory (CLT) principles provides an effective technique to assessing and improving cognitive load activities. Using eye-tracking technologies, researchers may visually watch and study where individuals concentrate, how long they spend on different content, and the patterns of eye movements during cognitive activity. In addition, the study shows that the fixation period affects the process of transferring known or unknown words from and into long-term memory (target memory) for saving the meaning without losing it over time. The results showed that reading text with contextual explanations improves the in-coding process of recognition and the development of translators' vocabulary. Accordingly, the modal amount of fixation required for the erudition of new vocabularies is calculated to be between 410 and 460ms. for the threshold process.

The present research findings can be beneficial for policymakers to consider the application of advanced technologies, i.e., eye-tracking, to better understand and assess the learning environment, as well as ensure the alignment of curricula with translation learners' cognitive abilities. Furthermore, educators can benefit from the findings of this study in implementing more effective, context-driven teaching strategies. These strategies can reduce unnecessary cognitive loads and enhance translation learners' engagement. Besides, educators can gain insight into how cognitive loads (extraneous, intrinsic, or germane) take place during translation activities. Likewise, eye-tracking can detect moments when students are deeply engaged in significant cognitive processes, indicating that topical load is being efficiently generated. Finally, by combining eye-tracking with cognitive load theory, educators may develop more personalized and productive educational settings that are tailored to their learners' cognitive processing capacities.

7. Future Insights

Future research should investigate the relationship between cognitive load, context, and translation proficiency, with the goal of improving learning settings and resources for aspiring translators. As the area progresses, the combination of cognitive science and technology will surely result in more effective and efficient translation procedures. One interesting avenue is to investigate individual characteristics, such as working memory capacity, cognitive styles, and language competence levels, to better understand how these aspects influence cognitive load during context-rich and context-poor translation tasks. Another subject worth exploring is the long-term development of cognitive load control among translation students. Most present research is cross-sectional, offering only snapshots of cognitive effort. Longitudinal designs would allow researchers to observe how translation training and exposure to contextually diverse texts affect cognitive efficiency over time. Such research could assist in discovering which pedagogical strategies are most effective at minimizing cognitive strain and increasing contextual awareness. Finally, there is a considerable demand for comparison research across language pairs and translation directions. Because cognitive load varies greatly depending on linguistic distance and syntactic structures, comparing different language contexts can show universal or language-specific cognitive problems.

Declarations

Author Contributions. Conceptualization, B. Kh. and L. A.; methodology, B. Kh.; software, L. A.; validation, analysis and visualization B. Kh. and I. M.; writing-original draft preparation, O.J.; writing-review and editing, R.F. All authors have read and agreed to the published version of the manuscript.

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