An instructional design for new cognitive structure construction in native language on second language learning

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**Abstract**

This study aims to design a second language instruction through the construction of new cognitive structures in the mother tongue and to determine its effect on the learner's cognitive load and achievement in learning complex structures. The study was undertaken in a public university in Istanbul with 79 prep school students and designed as a quasi-experimental study. A subjective cognitive load scale developed by Paas (1992) and an achievement test were utilized as the data collection tools. A covariance analysis (ANCOVA) was employed to determine student achievement between the experiment and control groups, the results of which produced a signiﬁcant diﬀerence in favor of the experiment group. The results of the one-way ANOVA showed that there is a statistically significant decrease with regards to the cognitive load of the students in the experiment group. The eﬃciency of instruction was also measured utilizing the efficiency formula developed by Paas and van Merrienboer (1994). The results corroborated the hypothesis that when designed in a way to construct new structures in the native language, thereby reducing the cognitive load, this instruction yields an increase in the achievement of the students for the learning of complex structures in the second language. The results call for attention that the instructional design utilized as the treatment of this study is efficient on the academic achievement of the students in their learning.

**Keywords:** Cognitive load; Instructional design; Instructional efficiency; Measurement of cognitive load; Second language instruction

**INTRODUCTION**

It has not been an easy task for adult language learners to process language forms of a second language to produce and comprehend them without difficulty while using the complex structures of the target language. Among such complex structures, one that causes difficulties and raises the learners' cognitive load is the relative clause (RC).

When the target language belongs to a language family different from the native language, this language structure (RC) creates more complexity in the process of learning. Learners who have Ural-Altaic languages as their mother tongue face some problems while mastering languages that belong to other language families such as English. While dealing with the problems related to such structural differences in the native and target languages, adult learners end up with an increased cognitive load, which is crucial to learn a second language.

According to the Cognitive Load Theory, when such new information does not fit into the currently available schemas, instructors should restructure existing schemas. In this way, they help learners by calling in their available cognitive forces; so that they spend less mental effort for the acquisition of complex structures (Sweller, 1999). Therefore, they should design instruction in such a way should be in alignment with learners' cognitive architecture (Kirschner et al., 2006). This was the starting point of this study through which the main conclusions were drawn depending on the results.

Therefore, underlying an instructional design theory, the present study first tries to offer an instructional design that brings a solution to learners' mastering complex grammatical structures in second language learning. By reducing the cognitive load of the adult learners through a new cognitive-structure in working memory, the design employs a method that uses the previously organized material in the long-term memory. It also helps learners successfully process the relative clauses during second language instruction. With these in mind, this study also aims to find out if this instruction decreases the cognitive load of adult learners by constructing new language structures in their native language. It also aims to help them organize their knowledge through instruction and acquire it as biologically secondary knowledge. In this way, that this instructional design approach would enable adult learners to acquire the target grammatical structure (Relative Clause) successfully despite the structural differences between these two languages without much mental effort.

***Related Literature***

CLT is an instructional theory that has instructional applications. According to this theory, the primary focus of the instruction is to construct a broad knowledge-store efficiently in the long-term memory. However, Sweller (2017) suggests that when we have limited working memory because of the narrow limits of the change principle, then we have an obstacle to achieving our aims. To avoid that, the borrowing-reorganizing principle provides the best way. Therefore, the information should be transferred to a learner directly. All applications of the theory include some ways to help reduce the load of working memory.

At this point, as to Sweller (2017), it is of high importance to realize that through the direct introduction of instruction, learners could better gain domain-specific knowledge to improve the impact of the borrowing principle. During the learning process of reading in a specific area, examples of particular textual knowledge in that area are required. That's why the principles of cognitive load theory are invaluable in showing the program designers the way that leads the learners to the desired outcomes of the learning processes.

According to human cognitive architecture theory, we have two main categories of knowledge: biologically primary and biologically secondary. Biologically primary knowledge is acquired easily without any effort as it is inherited at birth. On the other hand, biologically secondary knowledge is acquired with conscious effort and explicit instruction. Thus, learning a second language as an adult conforms to the structures and processes. It is associated with acquiring biologically secondary knowledge which employs some general rules of instruction to be applied to all stages of instruction.

There are also numerous general rules which apply specifically to adult learning of a second language. One of these rules is that we should devise instruction in such a way as to decrease the excessive burden on working memory (Sweller, 2017). Besides, written or spoken instruction should be clear and explicit according to one of the main principles of CLT; the borrowing and re-organizing principle. This principle asserts that once knowledge is obtained, it is usually re-organized by combining it with previously stored information. Based on this principle, learning a second language requires instructors to explicitly present the grammar topics and rules, as well as the vocabulary of the target language, instead of expecting learners to explore the information themselves (Kirschner et al., 2006).

Accepting the facts of the cognitive load theory (CLT), this study tries to purport that there could be alternative applications of language instruction especially when the native and the target languages belong to different languages such as Turkish and English to reduce the learners' cognitive load which complicates their learning process of this structure (RC). Therefore, the study significantly contributes to the field and presents new ideas for further applications of first language usage while learning complex structures that create cognitive load as well as recommending alternative ways of instructional design to reduce cognitive load. In line with this purpose, these three main questions were formulated:

1. Does the instructional design efficiently yield the learner success in learning complex structures through the construction of new cognitive structures in their native language during second language education?
2. Does the instructional design significantly affect learners' cognitive load in learning complex structures through the construction of new cognitive structures in their native language during second language education?
3. Do the cognitive load and success of students interact with each other to yield efficient instruction?

**MATERIALS and METHODS**

The study was designed as a quasi-experimental study. Quasi-experimental designs are commonly employed in evaluating educational programs when random assignment is not possible or practical (Gribbons and Herman, 1996) and when the efficiency of an intervention is sought for. This study employed a control, an experiment group, and a pre-post test administration.

The study consists of four stages shown in Table 1. At the first stage, a pre-test was conducted in both experiment and control groups, which was subsequently followed by the implementation of regular instruction in the control group, and a newly designed instruction in the experiment group as the second stage. As for the third stage, a post-test was applied as the achievement test of the study. In the final stage, the mental effort scale developed by Paas (1992) was implemented in both groups to receive the necessary data with regards to cognitive load.

The research had a quasi-experimental design, the dependent variables of which is the achievement and cognitive load of the students, while the independent variable is the instruction designed accordingly. The data were obtained through the implementation of the mental effort scale and administration of an achievement test to the experiment and control groups before and after a treatment which is the designed instruction. Throughout the process, only the subjects in the experiment group received treatment through the specifically designed instruction of relative clause unlike the subjects in the control group who received regular instruction. As the inferential statistics, covariance analysis (ANCOVA) was utilized to investigate any difference in the pre-test and post-test performance scores of the experiment and control groups. Pre-test results were used as the covariate variable to compare the post-test results of the experiment and control group and to investigate the effect of treatment on the performance of students.

Additionally, the results of the achievement test were used in the place of students' performance scores to identify their achievement. To determine if the cognitive load of the subjects reduced or not, Paas subjective cognitive load scale (1992) was used and analyzed through one-way ANOVA. Together with the results obtained from the achievement test, these results were also utilized in the Paas and Van Merrienboer formula (1994) to measure the instructional eﬃciency.

***Participant (subject) characteristics***

This study was undertaken at an English prep school of a public university in Istanbul in the spring semester of the 2019-2020 academic year. The English program of this university offers around 25 hours of intensive English language courses within a week. The program is administered in three different levels: A level (beginner), B level (intermediate), and C level (upper-intermediate) concerning the Common Europeans Framework (CEFR) standards. Learners in this program are the ones who could not succeed in the English language exam administered at the start of each academic year and were placed into the A-level classes according to the exam results. Since the A-level students had not learned the complex structures yet-as they start from scratch, the study focused on this level of the students to receive reliable data.

Since the study took place in a distance learning environment due to the pandemic, the subjects of the study were not randomly assigned to the groups, instead, they voluntarily signed up to the online sessions themselves as the sampling method of the study. All the subjects had had an opportunity to familiarize themselves with distance learning conditions with their teachers beforehand. It was because the School of the Foreign Languages had already switched to the means of online learning. The ids and passwords of the experiment and control group Zoom sessions were announced to the prep students through mentor teachers of A-level classes, and subjects chose their sessions based on their wishes and constituted the sample of the study. In total, 79 students participated in the study in the spring semester of the 2019-2020 academic year. There were 16 girls and 24 boys in the experiment group (N=40 in total), and 21 girls and18 boys in the control group (N=39 in total) coming from different departments of the university. All the participating subjects in the research study had Turkish as their first language.

***Data Collection Instruments***

In this research, the data were collected through an achievement test developed by the researcher to evaluate the student achievement. Additionally, Paas's mental effort scale was utilized to measure the cognitive load of the subjects and to determine the efficiency of instruction to test the asserted hypotheses of the research.

**Achievement Test**

To serve the purpose of the study, an achievement test was prepared by the researcher after a well-documented review of the literature (See Appendix E). As is suggested by Baysal (2001), to increase the reliability and validity of data collection instruments used in the language learning area, it is important to include different types of activities. Especially in the assessment of relative clause structure, it is highly recommended that three different data elicitation tasks should be employed (Baysal, 2001). Based on this, activities in the test included three different sections, in which students were to produce relative clause sentences. To elicit data from the students, a sentence combining task, a translation task, and a picture choosing task were preferred in these three sessions of the test. There are six items in each of the first two sections of the test, and four items in the third section. In total, there are 16 items in the achievement test of the study.

To assess the inter-rater reliability of agreement, Fleiss Kappa statistics were administered across the achievement test items. Fleiss Kappa statistics are used to analyze the inter-rater reliability when there are two or more raters and categories for nominal and ordinal data as it provides "the highest flexibility of the available reliability measures among the raters for such data” (Zapf, et. al., 2016). Since the study involved ordinal data and five experts rating the achievement test items, the Fleiss Kappa statistics were applied (Zapf, et. al., 2016). Fleiss' kappa was found to be (κ)=.79, p=.00, which represents a good strength of agreement with a 95% confidence interval from .63 to .94. Hence, it can be concluded that the achievement test items could measure the students' comprehension of relative clause word order. Therefore the content validity and the reliability of the test purports that the items are at highly acceptable levels.

A pilot study was also implemented with twenty-nine students to check the internal consistency reliability of the achievement test items and to see if the instructions were applicable. For this reason, the Kuder–Richardson Formula 20 (K-R 20) was applied to the responses to identify the reliability of the achievement test items which had dichotomous choices as true and false. The Kuder–Richardson reliability coeﬃcient of the student responses in the pilot study was found to be 0.77, at first. Items 4 and 5 in Section 1, and items 7 and 10 in section 2 were deleted from the original items list because of the time concerns in online lessons. When these items were deleted from the list, the K-R 20 reliability of the test increased to 0.80.

**Subjective Cognitive Load Scale**

Subjective scales are mostly preferred methods in measuring cognitive load in instructional design research. There is a variety of uni-dimensional and multidimensional scales, that have been developed and utilized to assess cognitive load. Yet, such scales were applied randomly to find possible differences amongst the three cognitive load types. However, previous research shows that subjective ratings have a better potential to differentiate between three cognitive load types when compared to task-based ratings.

To measure the cognitive load of the students during the instruction of relative clause structures, the nine-point Likert scale developed by Paas (1992) was utilized (See Appendix F). Although it is a subjective scale based on subjects' judgments, the mental effort spent by learners is accepted as a valid and reliable estimate of cognitive load by the experts (Paas and Van Merrienboer, 1994). For this reason, the subjects rated how much mental effort they thought they spent while doing the exercises during the instruction. They selected one of the nine options upon the completion of the study: " (1)very very low mental effort, (2)very low mental effort, (3)low mental effort, (4)rather low mental effort,(5) neither low nor high mental effort, (6)rather high mental effort, (7)high mental effort, (8)very high mental effort, and (9)very, very high mental effort" (Pass, 1992).

***Treatment***

In both groups, a lesson plan was prepared, and the instruction was carried out using PowerPoint slides in a Zoom session as a means of distance learning. The content of the materials of each group changed as the study focused on the efficiency of the instruction carried out throughout the process. Yet, the reinforcement activities were presented to the students at the end of each instruction. They were the same types of activities and exercises in both groups to eliminate any extraneous variables. In so doing, it was also aimed to obtain equality between the control and the experimental groups in terms of practice opportunities. In other words, to better understand how efficient the instruction was, and to decrease the possibility of giving privilege to any group through practices with specially designed activities, the students in both groups were provided with the same methods of teaching and sets of exercises after the instruction was completed.

Experiment Group: One of the most important aspects of this study is the instruction that was designed to scrutinize any changes in the learners’ cognitive load and to determine their performance in learning English. With this purpose in mind, the instruction was designed in a way that required learners to construct complex cognitive structures that are non-corresponding in their native language such as relative clauses, and hereby simulate similar syntactical structures in the target language. So that it was aimed to identify if the instruction was effective on the achievement of the learners and could reduce their cognitive load during second language learning. A lesson plan (See Appendix A) was prepared and its content was presented via PowerPoint presentation (See Appendix C).

According to the lesson plan of the experiment group, the instruction started with a brainstorming activity that helped students to increase their awareness about the fact that their native language and the target language belong to different language families (See Appendix A). By emphasizing the word orders and structural differences, the instructor gave examples in Turkish and asked students to make sentences. The aim here was to increase students' awareness that relative clause structures are not used in Turkish as they are used in the English language. Hence, the first step was to prepare the students for the construction of a new cognitive structure by using the structures that were available in the native language of the students. In other words, the instructor tried to help students get used to making sentences in Turkish first so that they would understand in what kind of situations relative clause structures are used in Turkish first. They would be able to apply this in constructing English relative clause sentences in this way.

To help students familiarize themselves with the structure of the target language, the most similar syntactical unit, namely –Kİ- structure in Turkish relative clause, was preferred. Although this usage is not morphologically sufficient and not commonly used in Turkish, it syntactically corresponds to English relative clause structures. To activate the schemata in the Turkish learners' minds and construct the new cognitive structure, examples of this usage are presented to the students. One example from the lesson plan is given below:

People **WHO** read books are more intellectual.

İnsanlar **Kİ** kitap okurlar, daha entelektüel-dir.

In this example, the word order is the most similar when the relative clause starts with –*Kİ*- structure. However, it is mostly taught as in the example below:

People **WHO** read books are more intellectual.

Kitap oku-y-an insanlar, daha entelektüel-dir.

When the relative clause is presented traditionally, it becomes even more complicated due to the word order. For this reason, the lesson plan was designed accordingly and the instructor presented the relative clause structures by giving such examples in the PowerPoint slides (See Appendix A and C).

Control Group: The materials of the control group included a lesson plan and PowerPoint slide presentations (See Appendix B and D). They were prepared by the researcher and checked by two more instructors. The lesson plan and its content were designed in parallel with the Curriculum Committee of the School of Foreign Languages. At the beginning of each term, the committee prepares the materials using different sources and provides the instructors with the plan and the materials. Depending on the dynamics of their classes, instructors prepare their daily plans with materials given by the committee. In this case, the instruction of the control group was designed according to the traditionally adapted curriculum. The samples were also extracted from the suggested sources.

***Data Analysis***

This research study employed quantitative data collection instruments: an achievement test and a mental effort scale. Descriptive analyses were made for all responses of the subjects and processed through SPSS (version 22). Inferential analyses, namely ANCOVA, were conducted to determine if there was a meaningful difference between the achievement test scores of the subjects in control and experiment groups with regards to their achievement in learning the relative clause structures. To investigate the cognitive load of the students after the treatment, the subjective cognitive load scale was utilized and the results were computed through one-way ANOVA.

To gauge instructional efficiency, a computational approach that was developed by Paas and Van Merrienboer (1994) was utilized. The formula “combines measures of mental effort with task performance to compare the mental efficiency of instructional conditions” (Paas and Van Merrienboer, 1993). The formula of instructional efficiency is E= (P-R)/√2.

(E) represents the relative instructional efficiency of a condition, while (P) is the performance measure that comes from the achievement test scores of the students, and (R) is the mental effort scores obtained from the Paas mental effort scale. The point here is that the performance and the mental effort measures should be converted into z-scores to calculate instructional efficiency. The result obtained from this formula identifies the efficiency of instructions carried out in each group and helps us compare their efficiency over the academic performance and achievement of students.

***Reliability and Validity of the Research***

Reliability and validity are by far the most fundamental test attributes. Reliability refers to how consistent test scores are from one to another (Bachman et.al., 1996). The validity, on the other hand, is often characterized as the degree to which a test measures what it aims to measure. Before all subsequent analyses for the research questions, a series of statistical operations were conducted to maintain the reliability and validity of the main research instrument. Figure 1 shows the statistical analyses performed for the achievement test utilized in this study.

To test the content validity of these items in the achievement test, expert opinion was received from five instructors who held a Ph.D. degree in ELT. They were asked to rate their agreement to the usefulness of the items used in the test on a five-point scale ranging from "(1) strongly disagree to (5) Strongly agree". All the items (N=16) of the achievement test were accepted as very useful and applicable by the experts as their averages ranged between 4.20 and 5,00.

Reliability estimates were also calculated for the achievement test. The data obtained from the instructors was quantitatively analyzed using Fleiss Kappa through SPSS 22. The inter-reliability of the test was found to be (κ)=.79, p=.00. Besides, a pilot study was implemented with twenty-nine students to check the internal consistency reliability of the achievement test items. The data obtained from the piloting study was analyzed with Kuder–Richardson Formula 20 (K-R 20) to further observe the relationships among the items measuring the constructs targeted in the achievement test. The reliability coeﬃcient of the student responses in the pilot study was found to be strong with a K-R 20= 0.80. As the results show, it can be said that the main research instrument maintained its validity and reliability.

**RESULTS**

***Outline of the Study Design and Procedure***

The purpose of this experimental study is to explore the impact of first language usage over the instruction of relative clause structures to see if this intervention decreases learner cognitive load and leads to the successful acquisition of this specific part of speech. To identify any differences between the experiment and control groups in terms of achievement, an achievement test was used in the study. It was administered to the A-level students of a prep school of a public university through online lessons. The results obtained from the test were computed through covariance analysis (ANCOVA). Additionally, to collect data about the cognitive load of the students in the experiment and control group, Paas subjective rating scale was administered before and after the instruction. The results received from the ratings were used to gauge if the designed instruction caused any decrease in the learners' cognitive load. To examine if the instruction that was designed with this purpose yielded an increase in the achievement of these learners while they are studying relative clauses used to determine if the instruction was efficient on student learning. To calculate this, the results were replaced into the formula of instructional efficiency.

***The Results for Research Question 1***

This research question aimed to reveal if the designed instruction yields any achievement in students' academic performance during the second language learning process. To see if there was a significant difference between the achievement scores of the experiment and control groups and that the treatment had a positive effect on student achievement, a covariant analysis was conducted. First of all, it was checked if the assumptions regarding the sample were met. It was seen that the groups were normally distributed and homogeneity of regression was statistically non-significant, which meant that ANCOVA could be conducted. Table 2 shows the ANCOVA results of the post-test scores of both groups.

The pre-test scores were considered as the shared variable, and post-test scores were the dependent variable. As the statistics indicate, there was a statistically significant difference (F(1,76)= 9.97 p< .05) between the post-test scores of the students in the experiment and the control group in favor of the experiment group. In other words, the results of the covariant analysis revealed that the experiment group was more successful in learning the target structures when compared with the control group.

***The Results for Research Question 2***

The second research question of this study focused on the identification of any reduction in the cognitive load of students who received an instruction that benefitted from the syntactical correspondence between the two languages in its design. It was hypothesized that by constructing new cognitive structures in the first language usage, students would require the least mental eﬀort to process the complex structures while learning a second language. To examine if the cognitive load is reduced through the instruction designed, one-way ANOVA was conducted, the results of which can be seen in Table 3.

When the data from the subjective rating scale were analyzed, the results produced statistically signiﬁcant diﬀerences between the two instructional formats used in the experiment and control groups, as F(15,63)=5.56, p=.00. According to Table 3, the p-value obtained indicated that students in the experiment group spent less mental eﬀort in the learning of complex structures in English when compared to the students who received regular instruction in the control group.

This ﬁnding supported another hypothesis of this research. Establishing syntactical similarity between the native and the target languages that belong to different language families required significantly less mental eﬀort than learning through the traditional instruction. In other words, the construction of a new cognitive structure, namely –Kİ- in Turkish, allows students to spend less mental effort and learn English relative clauses better. This ﬁnding is consistent with previous research which showed that by decreasing extraneous cognitive load, students can learn by using their all available cognitive forces and capacity during second language instruction.

As a result, the results obtained indicated that students who spent less mental effort employing the designed instruction signiﬁcantly outperformed the students in the control group who received regular instruction.

***The Results for Research Question 3***

The main aim of research question 3 was to identify the instructional efficiency of the program and the interaction between the cognitive load of the students and their academic success. Although the covariant analysis (ANCOVA) proved that the treatment administered in the experiment group was statistically significant, another analysis using the efficiency formula was conducted to further identify if reduced cognitive load also played an important factor together with the performance on the efficiency of instruction.

To measure instructional efficiency, the efficiency formula that was developed by Paas and Van Merrienboer (1994) was utilized. First, to find out the efficiency of the instruction, cognitive load ratings (R) and performance (P) scores are converted into z-scores and then calculated. This formula allows us to eliminate any threat which might be posed by self-conﬁdence or subjective comfort levels of the students rather than their cognitive load. As Kalyuga et al., (1998) explain, “if learners rate the mental eﬀort of a task as low, but perform well on the test (high eﬃciency), it means that they are rating cognitive load, not just self-conﬁdence” (as cited in Kablan and Erden, 2008). When the data obtained from the cognitive load scale and the post-test scores as the performance of the students were placed in the formula, the results for the experiment and control groups are as follow as shown in Table 4.

As shown in Table 4, when the necessary data were calculated, efficiency for the experiment group was found to be E= 0,31 for the experiment group, while the efficiency was E= -0,31 for the control group. This meant that “when the performance z-score is higher than the rating z-score, then instructional eﬃciency is positive, and when the performance z-score is lower than the rating z-score, then instructional eﬃciency is negative” (Kalyuga et al.,1998, as cited in Kablan and Erden, 2008). The results were demonstrated in Figure 2.

Figure 2 presents the result of instructional eﬃciency measurements in line with mental eﬀort and test performance scores of the students in the groups. Based on the results, the experiment group is located in the high-eﬃciency region which means that it has a relatively lower cognitive load and higher performance. Unlike the experiment group, the result for the control group is located in the low-eﬃciency region with more cognitive load and lower performance.

As a result, it can be concluded that the instructional design utilized as the treatment of this study is found to be efficient on the achievement of the students in their learning. The efficiency of the instruction could also be associated with reduced cognitive according to the results. So, the study reveals that when the students are presented with an instruction that deliberately tries to reduce their cognitive load by reconstructing the available cognitive structures in their minds through native language, then, the student performance could outweigh the performance of those who receive traditional instruction for a complex structure, namely the relative clause.

**DISCUSSION and CONCLUSION**

This research study was based on the main research motivation that has been hotly debated in the second language education field: Adults have a harder time learning a new language than children, and most learners never achieve native-level competency in another language (Ellis and Sagarra, 2011), but why is this the case?

As the studies in the field imply, it is the learners’ inter-language to be blamed which is defined as “the intermediate status of the learner’s language system between his first and second language” as Selinker (1974) puts forward; or there can be subjective, “learner-related—or (intra) individual—difficulties” in learning complex structures during the Second Language acquisition (as cited in Housen and Simoens, 2016). Yet, some language characteristics are cognitively more demanding than the learner characteristics which represent objective difficulty known as the notion of structural complexity (Housen and Simoens, 2016). This was considered as the starting point of this study through which the main conclusions were drawn depending on the results.

The first research question of this study, therefore, focused on the success of the students. It was shown that when instruction is designed to eliminate the structural differences between the native and target languages through the construction of new cognitive structures, this instructional design can help increase student achievement in return. Based on the results of the study, it was seen that when the subjects in the experiment group were taught the complex structures of the second language in such a way, they become more successful when compared to the subjects in the control group. Additionally, as students in the control group received traditional instruction, it was observed that they still had structural complexities related to the target language. These results are in line with the studies in the field. When the Second Language learners learn "grammar rules describing or explaining the linguistic features different from their first language, then the complexity of the target language structure increases as the complexity of its corresponding pedagogical rules are not the same" (Housen and Simoens, 2016). With this in mind, it should be concluded that an instructional design that aims to create cognitive structures in the native language similar to the ones in the target language plays an important role in the academic success of the students.

The second research question focused on another aspect of the instruction that was designed in this study. According to the hypothesis of the study, the cognitive load of learners can be reduced while learning complex structures of a second language through the construction of new cognitive structures in their native language. According to the results of the study, when the instruction is designed in a way to reduce the cognate load of the students, they require less mental eﬀort to process the complex structures in the second language. As suggested in the literature, working memory is limited when no executive decides how to use or organize the new information (Sweller, 1999. Therefore, when there is available prior knowledge that can act as an executive, it should be included "in the instruction to involve student participation" (Sweller, 1999). In other words, having to learn a complex structure in a second language that belongs to a different language family from the learner's language causes cognitive overload, which, in return, results in inefficient learning. For this reason, the instruction was deliberately designed to deal with the cognitive overload, and an alternative structure, namely –Kİ- structure, was suggested to reduce the load which affected the overall performance of the subjects. As the results imply the instruction designed in this study proved to be successful in controlling the high cognitive load consequently.

In this study, the –Kİ- structure that is already available in the mother tongue of the learners was used as the prior knowledge or the executive. This structure is not included in the regular relative clause instructions as it does not morphologically give a perfect exemplification of the structure. However, it was found out in the study that it syntactically corresponded very well to RC in the target language. It was obvious from the results that through activating the –Kİ- structure in their learning schemata in Turkish, students had a chance to familiarize themselves with how and where the very same structure is used in the target language. Based on the results of this study, when cognitive load is lowered via this type of RC instruction, learners could have more cognitive capacity left which could be invested in processes contributing to their learning.

When the test scores of the subjects who received the instruction designed in line with the principles of CLT were contrasted with those of the students who received traditional RC instruction, the results were also verified by the central tenet of CLT which asserts that "instruction needs to be organized in a manner that reduces unnecessary working memory load" (Kirschner et al, 2006). We can reach the same conclusion when looking at the results of this study. If the mental effort scores of the experiment and control groups are compared, it can be seen that the students in the control group reported investing higher mental effort as was indicated in the literature. At this point, it can be concluded that when the cognitive structures are constructed and reconstructed especially when the target language is a member of a different language family, it becomes possible to decrease the extraneous, (also known as external and secondary) and increase germane cognitive load that leads to higher performance.

The third research question tried to identify if the cognitive load and success of students interact with each other to yield efficient instruction. It was ensured with the results of the study that lowering the mental effort spent through actively constructing coherent mental representations leads to an increase in student achievement, which shows the efficiency of the instruction over successful learning. The results of the study could prove that "if an instruction does not provide enough guidance that shows a learner the structures and processes that support them to process language items", then learners end up exerting irrelevant or meaningless structures which charge extraneous cognitive load on learners' working memory (Brünken et al. 2003). It was found out that the more existing schemata are activated in the instruction, the lower the amount of cognitive load gets and the more successful students become in learning the complex structures of a target language that belongs to a different language family.

Consequently, the main conclusions of this study could be drawn as follows:

* When we design an instruction that helps learners create similar cognitive structures in their native language by activating their available cognitive forces, then, they academically become more successful in learning complex structures in the target language.
* When we manage the high cognitive load caused by the complexity of structures by tailoring our instruction as was administered in this study, then the mental effort that is spent by the learners can be reduced. This also affects the students' academic achievement positively.
* When the instruction is designed in alignment with learners' cognitive architecture, then the learners have a lower cognitive load and higher performance in language learning. This also proves the efficiency of tailored instruction.
* Such an instruction can also be administered in distance learning environments and become successfully efficient as long as the instruction is designed in a way that aims to reduce the cognitive load of learners through the construction of cognitive structures in native language while learning complex structures; and to increase academic performance in the processing of relative clauses.

***Implications for further studies***

Based on the results of the study, it was concluded that instructional strategies that help "reduce extraneous cognitive load and increase germane cognitive load" should be employed in second language education if we want to increase the performance of our students (Paas, 2003; Sweller 1999; Van Merrienboer and Sweller, 2005). In second language education, this implies that:

* Teachers should "explicitly present the grammar and vocabulary of the second language rather than expecting learners to induce the information themselves" (Kirschner et al., 2006).
* Second language learning necessitates "a conscious effort by learners and explicit teaching by instructors" (Sweller, 2017) which helps reduce the cognitive load of the learners and yields to better academic performance.
* Instructors should keep in mind that syntactically corresponding structures between the native and the target languages that belong to different language families influence the instructional efficiency by lowering the load and increasing the academic performance of the students.
* When the language curriculum is to be designed, the dimensions of cognitive load theory must be taken into consideration.
* Not only the relative clause structures but also some other structures that are considered complex in language learning can be taught by creating cognitive structures in the native language and activating the already existing schemata.

In such a case, it might be deduced that we are looking at the wrong places to identify the problems we have in language teaching. As a consequence, we should be aware of the facts that:

* Where grammatical structures are almost in reverse order due to belonging to different language families, the instructors should change their ways of tracing the problems in the instruction of the second language.
* That’s why it is also advisable to identify the problems in second language education, and include the cognitive aspects of the problems we encounter in our experiences in the field.
* We should underline the importance of reducing the cognitive load which might impede learning by taking the advantage of syntactical correspondences between the distinct languages to yield success.
* The awareness of the teachers should be increased on how important and effective it is to take into consideration the role of cognitive load in our teaching of complex structures.
* Even in a distance learning environment, the implementation of new cognitive structures to lower the load of the learners effectively can help students succeed in the acquisition of complex structures.

Additionally, it should also be noted that this study does not try to emphasize the use of the first language to explain grammatical issues. Rather, the results of this study may provide an insight to the teachers as well as the curriculum designers whose major consideration should be providing meaningful learning of complex structures when designing instruction, and benefitting from prior knowledge to reduce cognitive load and hereby increase the academic achievement.

In short, this research study could contribute to future directions in research and practice in the field by helping teachers, administrators and curriculum designers increase their awareness about how the principles of cognitive load theory are invaluable in the way that leads the learners to the desired outcomes of the learning processes in a successful way. So, as the study implies, through activities that are developed to emphasize correspondences in both languages and thereby activate the prior knowledge, we could provide students with a room to balance their cognitive capacity, and help not only the students to increase their academic achievement but also the instructors in the instruction of complex structures in the target language.

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**TABLES**

**Table 1.**Stages of the study

|  |  |  |
| --- | --- | --- |
| **Stage** | **Experiment group** | **Control group** |
| 1 | Pre-test administration | Pre-test administration |
| 2 | Treatment | Regular instruction |
| 3 | Post-test administration | Post-test administration |
| 4 | Implementation of the mental  effort scale | Implementation of the  mental effort scale |

**Table 2.** ANCOVA Results of the Achievement Test Scores.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source | Type III Sum of Squares | df | Mean Square | F | p | η2 |
| Pretest | 473.43 | 1 | 473.43 | 89.18 | .00 | .54 |
| GROUP | 52.91 | 1 | 52.91 | 9.97 | .00 | .12 |
| Error | 403.45 | 76 | 5.31 |  |  |  |
| Corrected Total | 933.47 | 78 |  |  |  |  |

**Table 3.** One Way ANOVA Results of the Cognitive Load Scale.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Sum of Squares | df | Mean Square | F | Sig. |
| Cognitive Load Scale | Between | 142.91 | 15 | 9.53 | 5.56 | .00 |
| Within | 107.94 | 63 | 1.71 |  |  |
| Total | 250.86 | 78 |  |  |  |

**Table 4.** Instructional Efficiency Results

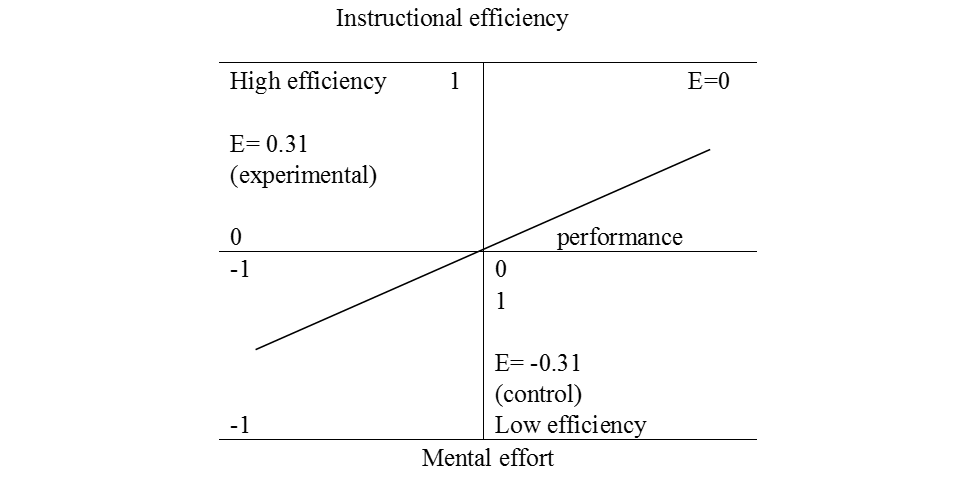
|  |  |  |
| --- | --- | --- |
| Efficiency | Formula | Result |
| Experimental group | 0.24 - (-0.19)  √2 | 0.31 |
| Control group | (-0.25) - 0.18  √2 | -0.31 |

**FIGURES**

Diagram

Description automatically generated

**Figure 1.** Reliability and Validity Operations for the Achievement Test.



**Figure 2.** Instructional Efficiency for the Experiment and Control Group.