

Diagnostic and Developmental Potentials of Computerized Dynamic Assessment (C-DA) for L2 Vocabulary

Karim Shabani^{1,*} 

¹ Allameh Mohaddes Nouri University, Nour, Iran.



10.22080/iselt.2022.23570.1035

Received

October 19, 2023

Accepted

December 24, 2023

Available online

December 28, 2023

Keywords

Computerized dynamic assessment, Electronic mediation, Vocabulary development, Learning potential score

Abstract

Computerized form of dynamic assessment (C-DA) has recently gained a foothold in second/foreign language (L2/FL) context. Inspired by Vygotskian socio-cultural epistemology, C-DA integrates assessment and instruction through providing learners with attuned electronic mediations. This study applied C-DA to assess and instruct L2 learners' vocabulary knowledge in reading comprehension tasks. Following a pretest–posttest control group design, the study included 70 participants who were randomly selected based on non-probability sample design from 125 students at the outset of the study. The experimental group (N=35) received the C-DA mediation and the control group (N=35) underwent a traditional, unmediated instruction. To be able to simultaneously assess and promote the learners' knowledge of vocabulary, a software program was designed, which could present a number of reading passages and offer strategically a wide range of hierarchically-based electronic mediations. The results of paired and independent samples t-test revealed significant improvement of the DA group. The information obtained from the learners' learning potential score (LPS) helped diagnose their emerging abilities, which evidenced that learners with equal actual scores in their independent performance had different mediated scores, gained score, and LPS. Moreover, the comparison of learners' non-dynamic assessment (NDA) and DA scores through both paired and independent samples t-test attested to the diagnostic function of C-DA in surfacing learners' underlying potential, a finding which has direct implications for L2 vocabulary assessment and development in EFL context.

1. INTRODUCTION

The L2 field is so obsessed with the development of standardized, high-stakes tests that the diagnostic mission of language testing has been consigned to oblivion. In this line, Alderson (2005) complains that such a sedate disposition and lackluster interest in diagnostic assessment in L2 testing has led to "a considerable confusion and indeed ignorance about what diagnostic testing might entail" (Alderson, 2005, p. 26). He goes further to state that even classroom-based

* **Corresponding Author:** Karim Shabani, English Department, Allameh Mohaddes Nouri University, Nour, Mazandaran, Iran, Email: shabanikarim@gmail.com



assessments have failed to put into effect principles of diagnostic assessment and no worthwhile attempt has been made to cater for the students' developmental needs. It is argued that traditional diagnostic assessments fail to fully capture the multilayer aspects of learners' performance due to their preoccupation with the psychometric notion of reliability and their deficiency-oriented approach to diagnosis (Kunnan & Jang, 2009, p. 622). The traditionally oriented diagnostic feedback treats learners' problems as homogenous and pays lip service to their individualized needs and underlying potentials. For this reason, the decisions and information accrued from such assessments lack pedagogical applications (Alderson, Brunfaut, & Harding, 2014).

The alternative view is anchored in Vygotsky's sociocultural theory and his learner-oriented notion of dynamic assessment (henceforth DA) through which the teacher participates or intervenes in the learner's activities to extend and broaden their learning abilities and at the same time diagnosing or assessing their development (van der Veen, Dobber, & van Oers, 2016). Dynamic assessment has established a solid niche in developmental psychology (Lidz, 1991; Sternberg & Grigorenko, 2002) but has only recently started gaining popularity among L2 scholars (e.g., Aljaafreh & Lantolf, 1994; Poehner, 2008; Antón, 2009; Mallahi, & Saadat, 2020) not least because of its robust theoretical background and effectiveness in assisting learners to develop new cognitive skills. DA parts company with the traditional static assessment on several grounds namely an emphasis on process rather than product, the inclusion of examiner feedback and a shift from examiner neutrality towards an individualized teaching and helping relationship (Grigorenko, Sternberg & Ehrman, 2000). What makes DA distinct from traditional assessment procedures is its underlying assumption that human abilities are dynamic and volatile rather than static. DA squarely attacked intelligence (IQ) testing for its tendency to present only a static measure of learners' abilities.

Vygotsky (1978) proposed that all learning takes place within a "zone of proximal development" which represents a distance between unmediated and mediated ability (Hasson & Botting, 2010). Vygotsky's notion of ZPD rests on the premise that learners' word recognition ability can be optimized with the provision of appropriate scaffoldings and mediation (Vygotsky, 1978). Computer and multimedia applications serve as examples of artifact mediation which has shown great potential in scaffolding L2 learners' vocabulary learning (e.g. Chun & Plass, 1996; Hulstijn, 1993, 1997; Knight, 1994; Laufer & Hill, 2000). Computer-mediated communication (CMC) is able to provide fine-tuned mediation to help learners reallocate their short-term memory to higher levels of textual analysis and interpretation and in this way reduce much of their learning constraints imposed by the need for word decoding and help boost their "sight vocabulary" capacity (Cummins, 1979; Li, 2010).

A computerized DA or C-DA integrates assessment and assistance with the aim of redressing the learners' linguistic deficiencies. C-DA has recently gained a foothold in foreign language teaching and learning (Shabani, 2014; Zheng, Niiya & Warschauer, 2015; Zheng & Warschauer, 2015; Yim & Warschauer 2017; Bakhoda & Shabani, 2016, 2017, 2019; Ebadi, & Saeedian, 2019; Vakili, & Ebadi, 2019; Estaji, & Saeedian, 2020; Zhang, & Zou, 2021). However, despite the aforementioned studies confirming the utmost potentials of C-DA few studies have been conducted to investigate its application in diagnosing and promoting L2 learners' vocabulary knowledge. Therefore, the present study was prompted to take a step towards uncovering the effect of computer-based mediations on L2 learners' vocabulary learning and examining the extent to which C-DA can bring to surface the learners' emerging abilities.

To meet the purposes of the present study, the following research questions were formulated:

1) Does computerized dynamic assessment (C-DA) have more significant effects on Iranian intermediate EFL learners' vocabulary knowledge than non-dynamic assessment (NDA)?

2) To what extent can C-DA diagnose Iranian intermediate EFL learners' vocabulary knowledge?

3) What types of mediations during C-DA can help improve Iranian EFL learners' vocabulary learning?

Theoretical Foundation of DA

The concept of DA originated from the Socio-cultural theory, and especially Vygotsky's zone of proximal development (ZPD). DA models have been greatly influenced by Vygotsky's theory of cognitive development (Vygotsky, 1986) and Feuerstein's Mediated Learning Experience (MLE, Feuerstein et al. 1979) which addresses the origins of differential cognitive developments (Feuerstein, Rand, & Hoffman, 1979).

ZPD is at the core of Vygotsky's Sociocultural Theory (SCT) which has been introduced by Vygotsky as a diagnostic tool that allows researchers and instructors to have a more vivid image of learners' developmental process and of the types of problems that prevent their cognitive growth. Vygotsky (1986) defines ZPD as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (as cited in Aljaafreh & Lantolf, 1994 p. 468).

ZPD views development "prospectively" and is contrasted with the learners' actual level of development (ZAD) that approaches learning "retrospectively". According to Kozulin (2003, p.17), the concept of ZPD gives three important pieces of information related to the dynamic testing: a) It draws our attention to the psychological functions of the child that are emerging at a given moment but that have not yet been fully developed; b) The concept of ZPD introduces assisted performance as an accepted parameter of assessment procedure; c) ZPD leads to conceptualize the difference between the level of actual performance and the learning potential of the child. ZPD is best captured through the SCT-based methodological procedure named dynamic assessment. DA distinguishes between a learner's unmediated (ZAD) and mediated (ZPD) performances.

As Poehner and Lantolf (2013) note, the difference between DA and other kinds of assessment lies in its interactive nature. Vygotsky discusses that "learner's responsiveness to the mediation signifies the development of his/her abilities presenting the processes underlying his/her performances". From DA perspective, ZAD shows an individual's independent performance but ZPD indicates what the individual is able to do under mediation. ZPD relies on diagnostic principles to detect the individual's potential level of development. The construct of ZPD echoes Vygotsky's SCT epistemology that instruction and assessment should be combined together for the sake of rendering a complete picture of the learner's underlying potential.

Poehner and Lantolf (2005) stated that static assessment (SA) represents a traditional view of assessment. The terms DA and static assessment (SA) were coined by researchers working on DA to differentiate between two different models of assessment. Sternberg and Grigorenko (2002) explain traditional SA as follows:

The examiner presents items, either one at a time or all at once, and each examinee is asked to respond to these items successively; without feedback or intervention of any kind. At some point in time after the administration of the test is over, each examinee typically receives the only feedback he or she will get: a report on a score or set of scores. By that time, the examinee is studying for one or more future tests (Sternberg & Grigorenko, 2002, p. vii).

In contrast, the authors define DA as a procedure whose outcome takes into account the results of an intervention. In this intervention, the examiner teaches the examinee how to perform better on individual item or on the test as a whole. The final score may be a learning score representing

the difference between pretest (before learning) and posttest (after learning) scores, or it may be the score on the posttest considered alone (ibid).

Therefore, DA is a procedure that simultaneously seeks the assessment and promotion of the learners' abilities. Moreover, it encourages learners to become independent knowledge constructors and problem solvers and, as an alternative to other testing procedure, it embeds mediation into the assessment as a tool to identify their full potential and nurture the abilities which are in the state of developing (Poehner & Lantolf, 2005).

Depending on the way the mediation is offered, DA can take different forms. Poehner and Lantolf (2005) have recognized two general approaches to DA: *Interventionist* or psychometric DA and *interactionist* or clinical DA. The main distinction between the two approaches is related to the way of providing mediation to students. In interactionist DA, the mediation between the learner and the teacher is negotiated and shaped *a posteriori*, while in interventionist DA it is determined in advance.

The interventionist DA has two models: 1) a formal and standardized approach in mediating learners in either forms of pre-test/treatment/post-test, which is called *sandwich* format, or 2) a set of pre-fabricated prompts embedded into the assessment procedures, called *cake* format. The famous advocate of interventionist approach is Milton Budoff. Budoff (1987) was more interested in planning a means to quantify and classify learners more precisely.

Computerized Dynamic Assessment (C-DA)

As an offshoot of DA, computerized dynamic assessment (C-DA) is founded on Vygotsky's theoretical framework (1978). Vygotsky and his colleagues developed a dynamic assessment by providing examinees with mediational prompts and hints during the assessment procedures in order to question the appropriateness of using a static IQ score to make predictions about the abilities of a child in succeeding at school (van der Veer & Valsiner, 1991). Vygotsky (1978) emphasized that a learner should be provided with structured intervention from mediators aiming at promoting his development. With the assistance of a mediator, a learner can proceed from his current level where he can't accomplish a task independently to a level where he can do the same task on his own. The focused intervention, emerging from a more mature counterpart, can be from a human, a cultural artifact, an object, or a tool.

In C-DA, individuals are given prefabricated hints and prompts (Mohammad Beigi, Molaei, & Yazdani, 2020; Kao, & Kuo, 2021). According to Poehner and Lantolf (2013), the advantage of interventionist approaches to DA over interactionist DA is that it can be simultaneously administered to a large group of individuals, especially in computerized format. Dixon-Krauss (1996) proposed the use of technology as a means to put into practice the concept of Vygotsky about planning lessons in such a way that facilitates instruction that is slightly above the learner's improvement. Crook (1991) also contended that within the ZPD computers can act much like a human partner or classroom teacher, and technology makes the computerized tool relevant to the mediation periods associated with internalization. Therefore, it is assumed that when human mediators are not accessible, computer-assisted devices can facilitate the social process necessary for development (Roud, & Hidri, 2021).

The applications of C-DA for educational and assessment purposes have been recently reported in the works of some researchers in cognitive psychology and L2 teaching. Tzuril and Shamir (2002), for instance, successfully tested the positive effect of electronic mediations on the kids' performance but claimed that without the presence of a human mediator it was impossible for the computerized mediation to become successful. Pishghadam and Barabadi's (2012) study attested to the construct validity of C-DA in bringing to surface the students' learning potential which had remained inchoate in their initial unmediated performance. Poehner, Zhang, and Lu (2015)

extended the applicability of C-DA to the reading and listening skills and reported different sets of scores for each learner including an actual score, a mediated score, a transfer score, and a learning potential score. However, they argued that their planned inventory of mediations may not be useful for other learners in a different context as they may find the task challenging for other reasons than the text and next C-DA studies are needed to expand their menu of mediating prompts. Boosting the applicability of C-DA to the domain of cognitive psychology, Bakhoda and Shabani (2016) examined the learners' response latency (RL) and processing time during C-DA of reading comprehension. Their developed software was able to discriminate between learners with larger and smaller ZPDs based on their processing time needed for each mediation. Taking the C-DA to the classroom context, Zhang and Lu (2019) reasoned that the diagnostic information gained through C-DA can be used for guiding the instructional practices.

Despite the various claims about the versatile functions of C-DA in testing diverse language skills, the existing research is still in its infancy and as far as vocabulary knowledge is concerned, there is a dearth of valuable studies, hence an exigent need to undertake the present research.

2. METHODOLOGY

Research Design

The present study was designed to quantitatively capture learners' vocabulary development through C-DA. To this end, a non-probability sample design incorporating A (the pretest), B (mediation) and A (posttest) was adopted in the present study. Moreover, the study followed Sternberg and Grigorenko's (2002, p. 27) cake format and Aljaafreh and Lantolf's (1994) hierarchical implicit-to-explicit regulatory scale to present the mediations. The following table sketches the overall design of the study for the two experimental and control groups:

Table 1: Overall design of the study

Session	Experimental group	Control group
Session 1	Pre-test	Pretest
Session 2	Mediation stage	Traditional approach
Session 3	Post-test	Post-test

Participants

At the outset of the study in late 2021, 125 L2 learners (female and male) between the ages of 19 and 25 from Iranian Language Institute, Chalus, Iran voluntarily agreed to participate in this study. To have a homogenous group, 70 students with 1 SD above and 1 SD below the mean based on the results of the Nelson Language Proficiency Test were selected. The students were then randomly divided into one DA group (N=35) and one control group (N=35). The following table displays demographic information about the participants. Table 2: Demographics of participants

Groups	N	Age	Male	Female	Level
Experimental	35	19-25	15	20	Intermediate
Control	35	19-25	12	23	Intermediate

Materials and Instruments

Computers and laptops were used as the main tools of the present study. Thirty five computers and laptops were used to present the technological vocabulary tasks to 35 students. The Nelson English proficiency test was administered to select a homogenous L2 group for this study. As a static pretest, a vocabulary test package consisting of 60 multiple choice items was developed by the researcher and two professionals in language testing to assess the students' developed word knowledge. Twelve reading passages were borrowed from Philips (2001) to be computerized for mediating purposes. The characteristics of the selected texts are presented in the following table.

Table 3: Coh-Metrix readability text analysis

Text	Narrativity	Systematic Simplicity	Word Correctness	Referential Cohesion	Deep Cohesion	Flesch Kincaid Grade Level	Number of words
1	33	27	88	94	89	9.5	305
2	35	33	76	77	63	8.2	156
3	22	17	54	64	59	7.9	264
4	30	40	79	85	70	9.6	197
5	21	32	88	81	54	7.7.	276
6	35	16	91	73	60	8.2	219
7	41	24	65	93	55	9.5	245
8	26	18	77	95	84	8.3	168
9	30	37	86	86	90	9.1	227
10	19	29	78	89	85	7.4	285
11	24	33	90	82	69	8.3	242
12	29	23	83	69	77	11.5	219

Coh-Metrix analysis measures discourse cohesion, syntax, semantics, word characteristics alongside the Flesch Kincaid readability of the selected texts. The content of passages consisted of different general subjects of psychology, zoology, history, geology, economy, and art. Each passage consisted of 8 questions. Altogether, the learners responded to 96 questions through C-DA procedure. After the mediation phase, both the control and experimental groups participated in the post-test, which was the same as the developed vocabulary test package. To reduce the practice effect, the posttest was administered two weeks later. The developed instruments were piloted before they were used in the current study in order to address the validity and reliability concerns.

Piloting

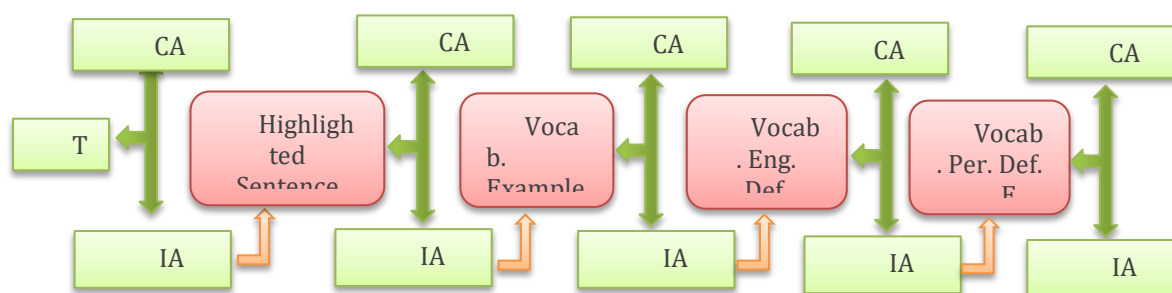
The vocabulary test consisted of content words which were selected from the content of C-DA passages. The vocabulary test package was piloted to 15 intermediate students, and based on the participants' answers to the pilot test, the researcher modified the items that were found either too difficult, attractive or ineffective. The following table represents the statistical reliability estimates of the pilot test.

Table 4: Results of Piloting

Number of learners	15
Number of items	60
Maximum score	60
Mean	23.6
KR-21 reliability coefficient	0.79

Procedure

After the selection of 70 participants based on the Nelson English proficiency test, they were randomly divided into two control and experimental groups. The reliability coefficients of the pretest calculated through Kuder-Richardson formula for the experimental and control groups were 0.78 and 0.75 respectively. After the pretest stage, the experimental group joined the C-DA procedure. Following Bakhoda and Shabani (2017), a software program was developed, with the use of C++ programming, to present the passages and the mediations. The following figure illustrates the designed exe application for current study. The learner's successful answer signaled the software to present the next question. The unsuccessful attempt was followed by presentation of a wide variety of pre-specified implicit to explicit vocabulary mediations. As the first implicit mediation, the sentence(s) that helped the learners the most to reach the correct answer was highlighted. The learners' incorrect answer to the question let the software present the second mediation which was more explicit than the previous one. The second mediation was presented after the learners clicked on the content vocabularies (any content vocabulary in the sentence could be clicked on to offer the mediations). By clicking on them, a simple sentence phrasing the selected word was presented on the screen to assist learners to understand both the words' meaning and concomitantly the sentence and reach the correct answer. The third mediation displayed the English definition of the words after clicking on them. Finally, the last mediation offered the learners the L1 (Persian) equivalent of the word. The following graph sketches the C-DA procedure:



Note: CA= correct answer; IA= incorrect answer

Figure 1: C-DA Procedure

The students went through this procedure to answer 96 questions related to the 12 passages. The regulator scale developed for the presentation of standardized, explicit-to-implicit mediations was as follows:

Table 5: Regulatory Scale of C-DA Mediations

Highlight specific sentences.
Provide examples.
Offer definitions.
Present L1 (Persian) equivalent.

The learners in control group received the same passages based on a traditional approach to reading comprehension. They were asked to read the passages; if they had a question about a vocabulary they were free to ask. But, the teacher tended to provide them with the Persian translation of the vocabularies as she followed a traditional method of instruction relying upon the learners' L1. The length of the C-DA test varied for each learner as they required more or less mediation.

A posttest was administered right after the treatment to assess whether or not both groups differed from each other after receiving two different treatments. They were told that for any wrong answer 1 score would be subtracted from the total score. The reliability coefficients of the post-test calculated through Kuder-Richardson for the experimental and control groups were 0.76 and 0.78 respectively.

Data Analysis

The statistical t-test was used to analyze the two groups' post-test performances as well as each group's pre and post-test scores. The scoring process of C-DA was taken from Poehner and Lantolf (2013). In order to quantitatively distinguish learners from each other based on their both developed and developing ability, the following three scores were given to each learner: ZAD score, ZPD score, and LPS. The ZAD score was calculated based on the learners' correct answer at their first attempt without mediation (5 points for the correct answer and 0 point for the incorrect one). Upon the learner's failure to find the correct answer and receiving mediation, 1 score was subtracted from the total 5 based on which the ZPD score was determined. For example, a learner who reached the correct answer after the first implicit mediation would have received 4 as his ZPD score. To quantitatively capture the learners' differential performance from NDA to DA session, the following LPS formula borrowed from Kozulin and Garb (2002) was used:

$$\text{LPS} = \frac{2 (\text{S post-mediation}) - \text{S actual}}{\text{Max S}}$$

Note. LPS: learning potential score; S: score.

Figure 2: LPS Formula
(Kozulin & Garb, 2002, p. 121)

3. RESULTS

Analysis of the first research question

The first research question asked if the C-DA had more significant effects on the learners' vocabulary knowledge than the NDA. At the outset, a pretest was administered to ensure the groups' parity before the treatment, and the scores were compared using an independent samples t-test, the result of which is summed up in the following table.

Table 6: Independent Samples t-test for the two groups' performances on the pretest

Group	N	Mean	S.D.	t value	D.F	P
Experimental	35	20.7	4.7	0.76069	34	.2247
Control	35	19.9	4.6			

The experimental and control groups were assessed based on the developed vocabulary test package (as a pretest) to precisely detect their developed vocabulary knowledge. The conducted t-test analysis indicated no significant difference ($t(34)=0.76$, $p=0.227$). Therefore, the two groups were not different in terms of vocabulary knowledge in the pretest.

To find any significant difference between the two groups in the posttest, an independent samples t-test was used.

Table 7: Independent samples t-test for the two groups' performance on the posttest

Group	N	Mean	S.D	T value	D.F.	P
Experimental	35	43.8	6.9	16.41	34	.0001
Control	35	20.71	4.5			

Based on the above table, the result of t-test revealed that there was a significant difference between the experimental ($M=43.8$, $SD=6.9$) and control group ($M=20.71$, $SD=4.5$); $t(34)=16.41$, $p=0.001$ on the posttest; hence, a significant difference between the two groups' posttest scores was confirmed. These results suggest that C-DA had a significant effect on the learners' vocabulary knowledge. To render a more vivid picture of the learners' difference from the pretest to the posttest, paired t-test was run. A comparison of the experimental group's pretest with its post-test performance yielded the following results:

Table 8: Paired Samples t-test for the experimental group's performance on the pre and posttest

Group	N	Mean	S.D	T value	D.F.	P
Experimental Pre-test	35	20.77	4.75	17.27	34	0.0001
Experimental Post-test	35	43.37	6.80			

The table indicates significant improvement of the experimental group from the pretest to the posttest ($M=20.77$, $SD=4.75$; $t(34)=17.27$, $p=0.0001$). This difference could be attributed to the effect of electronic mediations which guided the learners toward new ZAD levels. The same comparison was carried out for the control group to find out whether their post-test performance differed from their pre-test performance

Table 9: Paired samples t-test for the control group's performance on the pre and posttest

Group	N	Mean	S.D.	T value	D.F	P
Control Pretest	35	19.91	4.67	0.67	34	n.s.
Control Posttest	35	20.71	4.52			

No significant difference was found between the control group's pretest ($M=19.91$, $SD=4.67$) and post-test ($M=20.71$, $SD=4.52$) performances; $t(34)=0.67$, $p= n.s.$ It could be inferred that the traditional instruction of vocabulary through reading comprehension tasks did not lead to significant changes in the control group.

Based on the foregoing results, it was confirmed that computerized dynamic assessment (C-DA) had more significant effects on Iranian intermediate EFL learners' vocabulary knowledge than the non-dynamic assessment.

Analysis of the second research question

In order to answer the second research question and understand the extent to which C-DA can truly diagnose Iranian intermediate EFL learners' vocabulary knowledge, we compared the experimental group's mediated (DA) scores with their unmediated (NDA) scores.

The experimental group members systematically received scores based on the quality (im/explicitness) of the mediations they required to tackle the correct answer. In this regard, the learners' first attempt in each of the questions was interpreted as their NDA score, because no mediation was offered to them at this stage. The ZPD scores were calculated depending on the extent of mediations received. Allocating specific score for learners' ZAD and ZPD performance gave us a chance to compare learners' ZAD with their ZPD level through paired samples t-test.

Table 10: Paired samples t-test of learners' NDA and DA scores

Score	N	Mean	S.D.	T value	D.F.	P
NDA	35	195	18.41	148.6700	34	Sig
DA	35	343.67	17.24			

The results demonstrated that there is a significant difference between the learners' ZAD and ZPD scores. Kozulin and Garb's (2002) LPS formula was used to quantitatively assess the learners' vocabulary assisted performance. The calculated data provided us with the learners' mediated score based on their performance on the 96 questions. The following tables sum up the collected profiles of learners' performances.

Table 11. Learners' profile including the actual, mediated, gain score and LPS

Number of learners	35
Number of items	96
Maximum score	480
Mean of actual score	175
Mean of mediated score	343.67
Mean of gain score	168.23
Mean of LPS	0.91

The above table provides information about the number of learners and items, learners' maximum score, the calculated mean for learners' actual score, the calculated mean for mediated score, mean of gained score by learners, and learners' learning potential score. To understand the diagnostic potential of C-DA, a selection of the learners' actual score, mediated score, gain score, and learning potential score is provided in the following table.

Table 12: Selected learners' profile

Learner	Actual score	Mediated score	Gain score	LPS
1	95	325	230	1.15
2	100	318	218	1.11
3	110	299	189	1.01
4	110	271	161	0.9
5	95	279	184	0.96
6	130	232	102	0.69
7	155	244	89	0.69
8	195	297	102	0.83
9	200	269	69	0.70
10	200	316	116	0.9

It is noteworthy that learners with the same actual score (*ZAD*) demonstrated to have different mediated and LPS scores, which is related to their developing ability. More precisely, learners who performed at the same level independently differed dramatically with regard to their learning potential, or responsiveness to mediation. For example, learners 3 and 4 achieved the same actual score of 110, while their mediated and LPS differed from each other. This difference opens up two understandings; first, the LPS has the capacity to diagnose the learners' difference at the level of developing abilities and second, learners with different LPS scores might require different instructional mediations to move toward independency.

Following Kozulin and Garb (2002) and Poehner et al. (2015), we also sought the existence of any significant correlation between learners' mediated score and actual score. The calculated r (0.82) indicated a positive correlation between learners' ZAD and ZPD. Learners with higher actual developed ability proved to have higher mediated score.

Based on the abovementioned results, it was safe to conclude that C-DA can reliably diagnose Iranian intermediate EFL learners' vocabulary knowledge and distinguish between students with the same ZAD scores.

Analysis of the third research question

The third research question dealt with the types of mediations offered during the C-DA which helped improve the learners' vocabulary learning. It was revealed that presentation of a wide variety of electronic mediations assisted the learners to develop their vocabulary knowledge into a new zone. The following table sums up the learners' successful and unsuccessful attempts in the 12 reading comprehension passages (96 questions).

Table 13: Learners' performance over 96 reading comprehension questions

Texts	Q.	Without med.	First med.	Second med.	Third med.	Fourth med.
1	1	7	4	8	9	7
	2	3	7	7	14	4
	3	3	4	12	8	8
	4	5	8	9	10	3
	5	9	5	6	9	6
2	1	6	3	10	13	3
	2	8	7	5	6	9
	3	10	7	6	11	1
	4	3	11	9	5	7
	5	7	9	7	7	5
3	1	12	8	5	9	1
	2	8	5	4	13	5
	3	4	12	9	8	2
	4	9	10	9	7	-
	5	5	6	17	5	2
4	1	7	8	16	1	3
	2	6	11	10	7	1
	3	3	7	8	9	8
	4	8	14	10	1	2
	5	13	9	5	6	2
5	1	6	5	9	10	5
	2	7	8	7	9	4
	3	4	10	8	5	7
	4	8	8	11	7	1
	5	7	9	6	8	5
6	1	6	7	9	13	-
	2	10	4	11	8	2
	3	5	8	12	9	1
	4	3	14	8	10	-
	5	9	6	4	11	5
7	1	14	7	9	2	3
	2	8	13	7	6	1
	3	4	9	15	6	1
	4	8	15	9	3	-
	5	7	9	4	12	3
8	1	6	7	5	15	2
	2	11	5	6	8	5
	3	9	8	10	2	6
	4	3	16	7	5	4
	5	5	5	17	7	1
	1	6	9	7	8	5

Texts	Q.	Without med.	First med.	Second med.	Third med.	Fourth med.
9	2	10	13	9	2	1
	3	5	12	5	9	5
	4	8	7	12	8	-
	5	9	5	6	11	4
10	1	7	8	14	6	-
	2	12	6	4	12	1
	3	11	15	7	2	-
	4	4	12	8	5	7
	5	8	10	12	1	4
11	1	14	12	5	3	1
	2	10	7	13	5	-
	3	7	16	8	3	1
	4	13	10	11	-	1
	5	9	17	6	3	-
12	1	5	15	7	5	3
	2	8	9	10	3	5
	3	10	5	8	11	1
	4	6	8	9	8	4
	5	7	7	12	6	3

Altogether, four types of mediations were offered namely *highlighting the sentence, providing example, offering definition and presenting L1 (Persian) equivalent*. As can be seen in the Table, some learners required less or more explicit mediations to arrive at the correct answer. For example, in question 5 of Text 11 the learners needed more implicit mediations (1st mediation = 17) whereas they needed more explicit mediations for question 2 of Text 3 (3rd mediation = 13). The effectiveness of electronic vocabulary mediations during the reading comprehension is presented in the following graph:

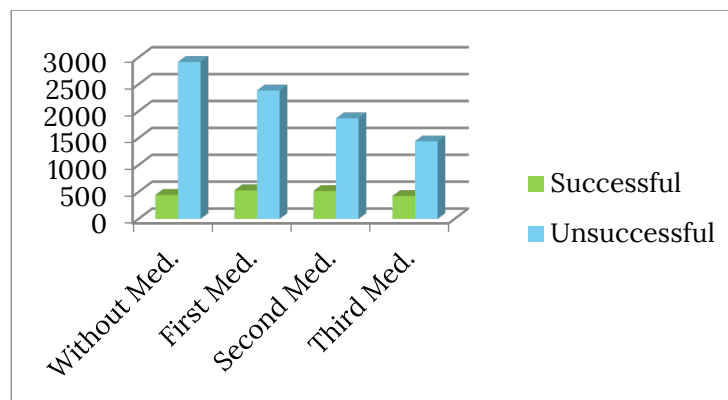


Figure 3: Learners' performance on 96 reading comprehension questions

Figure 3 presents detailed information about the learners' performance on 96 reading comprehension questions. As illustrated in the Figure, a considerable number of learners were not able to reach the correct answer independently at their first attempt but the vocabulary mediations gradually helped them to find the correct answer. The blue bars represent the number of learners' unsuccessful attempts to accomplish the task. As clearly demonstrated in the graph, learners'

unsuccessful attempts decreased toward the last mediation. The frequency of mediational moves is presented in the following table to demonstrate the learners' enhanced performance.

Table 14: Quality and frequency of mediations on 96 reading comprehension questions

Texts	Q.	No med.	Highlighted Sentence	Vocab. Example	English Definition	Persian Definition
1	1	7	4	8	9	7
	2	3	7	7	14	4
	3	3	4	12	8	8
	4	5	8	9	10	3
	5	9	5	6	9	6
2	1	6	3	10	13	3
	2	8	7	5	6	9
	3	10	7	6	11	1
	4	3	11	9	5	7
	5	7	9	7	7	5
3	1	12	8	5	9	1
	2	8	5	4	13	5
	3	4	12	9	8	2
	4	9	10	9	7	-
	5	5	6	17	5	2
4	1	7	8	16	1	3
	2	6	11	10	7	1
	3	3	7	8	9	8
	4	8	14	10	1	2
	5	13	9	5	6	2
5	1	6	5	9	10	5
	2	7	8	7	9	4
	3	4	10	8	5	7
	4	8	8	11	7	1
	5	7	9	6	8	5
6	1	6	7	9	13	-
	2	10	4	11	8	2
	3	5	8	12	9	1
	4	3	14	8	10	-
	5	9	6	4	11	5
7	1	14	7	9	2	3
	2	8	13	7	6	1
	3	4	9	15	6	1
	4	8	15	9	3	-
	5	7	9	4	12	3
8	1	6	7	5	15	2
	2	11	5	6	8	5
	3	9	8	10	2	6
	4	3	16	7	5	4
	5	5	5	17	7	1

Texts	Q.	No med.	Highlighted Sentence	Vocab. Example	English Definition	Persian Definition
9	1	6	9	7	8	5
	2	10	13	9	2	1
	3	5	11	5	9	5
	4	8	7	12	8	-
	5	9	5	6	11	4
10	1	7	8	14	6	-
	2	12	6	4	12	1
	3	11	15	7	2	-
	4	4	12	8	5	7
	5	8	10	12	1	4
11	1	14	12	5	3	1
	2	10	7	13	5	-
	3	7	16	8	3	1
	4	13	10	11	-	1
	5	9	17	6	3	-
12	1	5	15	7	5	3
	2	8	9	10	3	5
	3	10	5	8	11	1
	4	6	8	9	8	4
	5	7	7	12	6	3

As shown in the above table, the learners required less explicit mediations for the 8-12 passages, which could be considered as their cognitive development in grasping the meaning of vocabularies from the context of passages.

4. DISCUSSION AND CONCLUSION

This study was designed to investigate whether providing electronic vocabulary mediations leads to learners' vocabulary development. The learners were involved in reading comprehension tasks where their failure in finding the correct answer was responded through a wide variety of computer-based vocabulary mediations.

The obtained results demonstrated that there is a significant difference between NDA and DA results. The NDA assessment is able to distinguish learners with reference to their current developed abilities, but it is unable to uncover learners' developing abilities. On the other hand, DA assessment provides a more comprehensive view of learners' both independent abilities and underlying potential through integration of assessment and instruction. The comparison of NDA results in the pretest with the DA findings indicated that the information collected about learners' potentiality in DA was quite revealing. According to Poehner (2008), DA assessment brings to surface both learners' ZAD and ZPD. Computerized electronic vocabulary mediations through reading comprehension tasks assisted the learners to develop new ZAD and ZPD levels. Based on the evidence presented in the results, LPS quantitatively differentiated learners from each other. Following Kozulin and Garbs's (2002) proposed formula for LPS consisting of high (≥ 1.0), mid (.71-.8) and low ($\leq .71$), the average calculated LPS for 35 learners (0.91) in the experimental group demonstrated that their vocabulary knowledge highly improved. Also, it became clear that learners with the same ZAD scores (for example, learner 1, 2, and 5) based on their independent performance had different mediated scores, gain score, and LPS. In other words, learners' dependent performance was brought to surface through the C-DA procedure. Generally, the C-DA

procedure set the stage for appropriately responding to the learners' needs in carrying out the reading tasks and in this way assisting them to co-construct new ZPDs. Such layers of vocabulary learning abilities had remained inchoate during the NDA stage. These observations are found commensurate with the results of C-DA studies that have reported similar results for other language domains such as English tenses (Mohammad Beigi, Basirloo, Molaei & Yazdani, 2020), L2 listening (Poehner, Zhang, & Lu, 2015; Kamroud, Davoudi, Ghaniabadi & Amirian, 2019; Kao & Kuo, 2021; Roud & Hidri, 2021), L2 writing (Vakili & Ebadi, 2019; Ebadi & Bashir, 2020; Hidri & Roud, 2020), L2 reading (Ebadi & Saeedian, 2019; Yang & Qian, 2019; Estaji & Saeedian, 2020; Yaghoobi & Razmjoo, 2020) and interlanguage pragmatics (Zangoei, Zareian, Adel & Amirian, 2019).

Learners' vocabulary enhancement in the experimental group could be attributed to the presentation of hierarchical implicit-to-explicit mediations. The strategic mediations based on Aljaafreh and Lantolf's (1994) regulatory scale were found effective in the context of vocabulary instruction/assessment. The pre-specified electronic mediations helped the learners reach new developmental zones. The C-DA procedure was able to render a rich profile for each learner capturing the learners' ZAD, ZPD, and LPS. As Poehner (2008) discussed, one of the advantages of electronic presentation of mediation is to generate an automatic profile for learners while facilitating their development.

The effectiveness of hierarchical presentation of implicit to explicit electronic vocabulary mediations on both learners' reading comprehension ability and vocabulary knowledge echoed Aljaafreh and Lantolf (1994) and Sternberg and Grigorenko's (2002) claim about the effectiveness of this procedure on learners' cognitive modification. The study also substantiates Zhang and Annual (2008), Martin-Chang and Gould (2008), and Joshi and Aaron's (2000) claim that vocabulary development and reading comprehension are closely related. Therefore, combining assessment and instruction can be beneficial for EFL learners in vocabulary learning.

One major contribution of the findings reported in the present study is the inherent potential of C-DA procedure to be administered to large numbers of students simultaneously in the context of vocabulary assessment and to report the results in a quantitative format that is easily interpretable. The C-DA incorporated diagnosis and promotion of vocabulary learning abilities through a system of graduated prompting, an instructional-evaluation procedure that can be considered as a replacement for the conventional teacher-fronted instruction and unmediated assessment methodology in Iranian EFL context. The present study showcased a sample potential of computer as a tool to replace humans in presenting scaffolds. However, there are diverse features in the computer which can be offered to the learners in an EFL context to boost their learning of vocabulary among which is the Google Expeditions virtual reality (Ebadi & Ebadijalal, 2020) or Metaverse whose efficacy via C-DA serves as a potential site to explore.

A supplementary feature which can be added to the C-DA software reported in this study is the assessment of testees' response latency after receiving the mediation and before reaching the correct answer. The results from the observation of students' processing time and response latency can further increase the discriminatory validity of the C-DA. The results drawn from the LPS scores could be used for placement purposes and tailoring remedial instruction attuned to the ZPD to the prospective learners since different learners with different LPS scores might require different degrees of mediated instruction.

References

- Alderson, J. C. (2005). *Diagnosing foreign language proficiency: The interface between learning and assessment*. Continuum.
- Alderson, J. C., Brunfaut, T., & Harding, L. (2014). Towards a theory of diagnosis in second and foreign language assessment: Insights from professional practice across diverse fields. *Applied Linguistics*, 36(2), 236-260. <https://doi.org/10.1093/applin/amt046>
- Aljaafreh, A., & Lantolf, J. P. (1994). Negative feedback as regulation and second language learning in the zone of proximal development. *Modern Language Review*, 78, 465-483. <https://doi.org/10.2307/328585>.
- Antón, M. (2009). Dynamic assessment of advanced language learners. *Foreign Language Annals*, 42(3), 576–598. <https://doi.org/10.1111/j.1944-9720.2009.01030.x>
- Bakhoda, I., & Shabani, K. (2016). Response latency as a tool to study L2 learners' ZPD, ZAD and ongoing information processing. *Asian-Pacific Journal of Second and Foreign Language Education*, 1(2). <https://doi.org/10.1186/s40862-016-0009-4>.
- Bakhoda, I., & Shabani, K. (2017). Enhancing L2 learners' ZPD modification through computerized-group dynamic assessment of reading comprehension. *Innovation in Language Learning and Teaching*, 13(1), 52-69. <https://doi.org/10.1080/17501229.2017.1286350>
- Bakhoda, I., & Shabani, K. (2019). Bringing L2 learners' learning preferences in the mediating process through computerized dynamic assessment. *Computer Assisted Language Learning*, 32(3), 210-236. <https://doi.org/10.1080/09588221.2018.1504225>
- Best, J. W., & Kahn, J. V. (2006). *Research in education* (10th ed.). Pearson Education.
- Bisson, M., van Heuven, W. J. B., Conklin, K., & Tunney, R. J. (2014). The role of repeated exposure to multimodal input in incidental acquisition of foreign language vocabulary. *Language Learning*, 64, 855–877. <https://doi.org/10.1111/lang.12085>
- Budoff, M. (1987). The validity of learning potential. In C. S. Lidz (Ed.), *Dynamic assessment: An interactional approach to evaluating learning potential* (pp. 52-81). Guilford Press.
- Chun, D. M., & Plass, J. L. (1996). Effects of multimedia annotations on vocabulary acquisition. *Modern Language Journal*, 80, 183–198. <https://doi.org/10.1111/j.1540-4781.1996.tb01159.x>
- Crook, C. (1991). Computers in the zone of proximal development: Implications for evaluation. *Computers & Education*, 17(1), 81-91. [https://doi.org/10.1016/0360-1315\(91\)90075-3](https://doi.org/10.1016/0360-1315(91)90075-3)
- Cummins, J. (1979). Linguistic interdependence and the educational development of bilingual children. *Review of Educational Research*, 49, 222–251. <https://doi.org/10.3102/00346543049002222>
- Dixon-Krauss, L. (1996). *Vygotsky in the classroom: Mediated literacy instruction and assessment*. Addison Wesley Longman.
- Ebadi, S., & Bashir, S. (2021). An exploration into EFL learners' writing skills via mobile-based dynamic assessment. *Education and Information Technologies*, 26(2), 1995-2016. <https://doi.org/10.1007/s10639-020-10349-3>
- Ebadi, S., & Ebadijalal, M. (2020). The effect of Google Expeditions virtual reality on EFL learners' willingness to communicate and oral proficiency. *Computer Assisted Language Learning*, 1-25. <https://doi.org/10.1080/09588221.2020.1854311>
- Ebadi, S., & Saeedian, A. (2016). Planning future instructional programs through computerized L2 dynamic assessment. *Teaching English with Technology*, 16(4), 12-32.
- Ebadi, S., & Saeedian, A. (2019). Exploring L2 learning potential through computerized dynamic assessment. *Teaching English Language*, 13(2), 51-78. <https://doi.org/10.22132/TEL.2019.95883>

- Estaji, M., & Saeedian, A. (2020). Developing EFL learners' reading comprehension through computerized dynamic assessment. *Reading Psychology*, 41(4), 347-368. <https://doi.org/10.1080/02702711.2020.1768988>.
- Feuerstein, R., Rand, Y., & Hoffman, M. B. (1979). *The dynamic assessment of retarded performers: The learning potential assessment device, theory, instruments, and techniques*. University Park Press.
- Grabe, W., & Stoller, F. (1997). Reading and vocabulary development in a second language: A case study. In J. Coady & T. Huckin (Eds.), *Second language vocabulary acquisition: A rationale for pedagogy* (pp. 98–122). Cambridge University Press.
- Grigorenko, E. L., Sternberg, R. J., & Ehrman, M. E. (2000). A theory-based approach to the measurement of foreign language learning ability: The CANAL-FT theory and test. *The Modern Language Journal*, 84, 390-405. <https://doi.org/10.1111/0026-7902.00076>
- Hasson, N., & Botting, N. (2010). Dynamic assessment of children with language impairments: A pilot study. *Child Language Teaching and Therapy*, 26(3), 249-272. <https://doi.org/10.1177/0265659009349982>
- Hidri, S., & Roud, L. F. P. (2020). Developing and using hints in computerized dynamic assessment of a TOEFL iBT reading exam. *Heliyon*, 6(9), e04985. <https://doi.org/10.1016/j.heliyon.2020.e04985>
- Hulstijn, J. H. (1993). When do foreign-language readers look up the meaning of unfamiliar words? The influence of task and learner variables. *Modern Language Journal*, 77, 139–147. <https://doi.org/10.1111/j.1540-4781.1993.tb01957.x>.
- Hulstijn, J. H. (1997). Second language acquisition research in the laboratory: Possibilities and limitations. *Studies in Second Language Acquisition*, 19, 131–143. <https://doi.org/10.1017/S0272263197002015>
- Joshi, R. M., & Aaron, P. G. (2000). The component model of reading: Simple view of reading made a little more complex. *Reading Psychology*, 21, 85–97. <https://doi.org/10.1080/02702710050084428>
- Kao, Y. T., & Kuo, H. C. (2021). Diagnosing L2 English learners' listening difficulties and learning needs through computerized dynamic assessment. *Interactive Learning Environments*, 1-25. <https://doi.org/10.1080/10494820.2021.1876733>
- Knight, S. (1994). Dictionary use while reading: The effects on comprehension and vocabulary acquisition for students of different verbal abilities. *Modern Language Journal*, 78, 285–299. <https://doi.org/10.1111/j.1540-4781.1994.tb02043.x>
- Kozulin, A. (2003). Psychological tools and mediated learning. In A. E. Kozulin, B. E. Gindis, V. S. E. Ageyev, & S. M. E. Miller (Eds.), *Vygotsky's educational theory in cultural context* (pp. 83-98). Cambridge University Press.
- Kozulin, A., & Garb, E. (2002). Dynamic assessment of EFL text comprehension of at-risk students. *School Psychology International*, 23, 112–127. <https://doi.org/10.1177/0143034302023001733>
- Kunnan, A. J., & Jang, E. E. (2009). Diagnostic feedback in language assessment. In M. H. Long & C. J. Doughty (Eds.), *The handbook of language teaching* (pp. 610–627). Wiley-Blackwell.
- Laufer, B., & Hill, M. (2000). What lexical information do L2 learners select in a CALL dictionary and how does it affect word retention? *Language Learning & Technology*, 3(2), 58–76.
- Li, J. (2010). Learning vocabulary via computer-assisted scaffolding for text processing. *Computer Assisted Language Learning*, 23, 253-275. <https://doi.org/10.1080/09588221.2010.483678>

- Lidz, C. S. (1991). *Practitioner's guide to dynamic assessment*. Guilford Press.
- Mallahi, O., & Saadat, M. (2020). Effects of feedback on Iranian EFL learners' writing development: Group dynamic assessment vs. formative assessment. *Iranian Evolutionary and Educational Psychology Journal*, 2(4), 258-277. <https://doi.org/10.52547/ieepj.2.4.258>
- Martin-Chang, S. L., & Gould, O. N. (2008). Revisiting print exposure: Exploring differential links to vocabulary, comprehension and reading rate. *Journal of Research in Reading*, 31(3), 273-284. <https://doi.org/10.1111/j.1467-9817.2008.00371.x>.
- Mehri Kamroudi, A., Davoudi, M., Ghaniabadi, S., & Amirian, S. M. R. (2019). Diagnosing L2 learners' development through online computerized dynamic assessment. *Computer Assisted Language Learning*, 1-30. <https://doi.org/10.1080/09588221.2019.1645181>
- Mohammad Beigi, A., Molaei, A., & Yazdani, S. (2020). Effect of interventionist computerized dynamic assessment on learners' grammatical English tenses: Analysis of cake and sandwich formats. *International Journal of Foreign Language Teaching and Research*, 8(32), 79-91.
- Philips, D. (2001). *Longman preparation course for the TOEFL test*. Longman.
- Pishghadam, R., & Barabadi, E. (2012). Constructing and validating computerized dynamic assessment of L2 reading comprehension. *Iranian Journal of Applied Linguistics (IJAL)*, 15(1), 73-95.
- Poehner, M. E. (2008). *Dynamic assessment: A Vygotskian approach to understanding and promoting second language development*. Springer Publishing.
- Poehner, M. E., & Lantolf, J. P. (2005). Dynamic assessment in the language classroom. *Language Teaching Research*, 9(3), 233-265. <https://doi.org/10.1191/1362168805lr166oa>
- Poehner, M. E., & Lantolf, J. P. (2013). Bringing the ZPD into the equation: Capturing L2 development during computerized dynamic assessment. *Language Teaching Research*, 17(3), 323-342. <https://doi.org/10.1177/1362168813482935>
- Poehner, M. E., Zhang, J., & Lu, X. (2015). Computerized dynamic assessment (C-DA): Diagnosing L2 development according to learner responsiveness to mediation. *Language Testing*, 32(3), 337-357. <https://doi.org/10.1177/0265532214560390>
- Roud, L. F. P., & Hidri, S. (2021). Toward a sociocultural approach to computerized dynamic assessment of the TOEFL iBT listening comprehension test. *Education and Information Technologies*, 26, 7059-7084. <https://doi.org/10.1007/s10639-021-10607-y>
- Shabani, K. (2014). Dynamic assessment of L2 listening comprehension in transcendence tasks. *Procedia - Social and Behavioral Sciences*, 98, 1729-1737. <https://doi.org/10.1016/j.sbspro.2014.03.600>
- Sternberg, R. J., & Grigorenko, E. L. (2002). *Dynamic testing: The nature and measurement of learning potential*. Cambridge University Press.
- Tzuriel, D., & Shamir, A. (2002). The effects of mediation in computer assisted dynamic assessment. *Journal of Computer Assisted Learning*, 18(1), 21-32. <https://doi.org/10.1046/j.0266-4909.2001.00204.x>
- Vakili, S., & Ebadi, S. (2019). Exploring EFL learners' developmental errors in academic writing through face-to-face and computer-mediated dynamic assessment. *Computer Assisted Language Learning*, 1-36. <https://doi.org/10.1080/09588221.2019.1698616>.
- Van der Veen, C., Dobber, M., & van Oers, B. (2016). Implementing dynamic assessment of vocabulary development as a dialogical learning process: A practice of teacher support in primary education schools. *Language Assessment Quarterly*, 13(4), 329-340. <https://doi.org/10.1080/15434303.2016.1235577>

- Van der Veer, R., & Valsiner, J. (1991). *Understanding Vygotsky: A quest for synthesis*. Blackwell Publishing.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Vygotsky, L. S. (1986). *Thought and language* (A. Kozulin, Ed.). MIT Press.
- Yaghoobi, M., & Razmjoo, A. (2020). Dynamic assessment, computerized dynamic assessment, static assessment and reading comprehension: Effects and percepts. *Journal of Research in Educational Systems*, 14(49), 25-39.
- Yang, Y., & Qian, D. D. (2020). Promoting L2 English learners' reading proficiency through computerized dynamic assessment. *Computer Assisted Language Learning*, 33(5-6), 628-652. <https://doi.org/10.1080/09588221.2019.1585882>
- Yim, S., & Warschauer, M. (2017). Web-based collaborative writing in L2 contexts: Methodological insights from text mining. *Language Learning & Technology*, 21(1), 146-165.
- Zangoei, A., Zareian, G., Adel, S. M. R., & Amirian, S. M. R. (2019). The impact of computerized dynamic assessment on Iranian EFL learners' interlanguage pragmatic development. *Journal of Modern Research in English Language Studies*, 6(4), 165-139.
- Zhang, J., & Lu, X. (2019). Measuring and supporting second language development using computerized dynamic assessment. *Language and Sociocultural Theory*, 6(1), 92-115. <https://doi.org/10.1558/lst.37783>
- Zhang, L. J., & Annual, S. B. (2008). The role of vocabulary in reading comprehension. *RELC Journal*, 39, 51-76. <https://doi.org/10.1177/0033688208091140>
- Zhang, R., & Zou, D. (2021). Types, features, and effectiveness of technologies in collaborative writing for second language learning. *Computer Assisted Language Learning*, 1-31. <https://doi.org/10.1080/09588221.2020.1863239>
- Zheng, B., & Warschauer, M. (2015). Participation, interaction, and academic achievement in an online discussion environment. *Computers & Education*, 84, 78-89. <https://doi.org/10.1016/j.compedu.2015.01.008>.