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Development of a Computerized Dynamic Reading Assessment Program to Measure English Reading Comprehension of Thai EFL Undergraduate Students

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Abstract

The present study aimed to determine the effects of a computerized dynamic reading assessment (CDRA) program on English reading comprehension of university students with a lower level of English proficiency. Fulcher's (2003) framework was adapted in program development divided into three phases: program development, program implementation, and program evaluation. An intact group of 30 Thai EFL undergraduate students with a lower level of English proficiency participated in this mixed-methods study which employed a test-train-test approach. Quantitative data collected from non-dynamic assessment (DA) pre- and post-tests as well as five DA tests were analyzed by means of inferential statistics, while qualitative data elicited from the questionnaire and interview protocol were analyzed using descriptive statistics and content analysis. The findings revealed that the CDRA program had a positive effect on the students' reading comprehension, as demonstrated by the post-test results and a large effect size. Qualitative analysis revealed that the students had a positive perspective on the advantages offered by the CDRA program, expressed a preference for the software, and offered opinions and suggestions for further improvement. The findings of this study yield implications and recommendations for EFL instructors of English reading courses regarding the design of the CDRA programs interface and its utilization.

INTRODUCTION

Assessment of English reading abilities is a vital component of reading instruction, as assessment can play a vital role in learners' lives (McNamara, 2000; Watson Todd, 2014), not only as a channel to certify learning achievement but also as a means to inform instructors if learners need assistance while they are still in the learning process. For these reasons, assessment needs to be effectively implemented in reading instruction to help increase learners' chance of success. In most EFL classrooms, traditional assessment methods are used to measure the language skills and knowledge that EFL learners have developed or acquired from their learning

experiences. As regards EFL reading assessment in particular, traditional tests such as multiple-choice test items are valuable for measuring lower-level reading comprehension skills, such as identifying main ideas, specific details, and vocabulary in context. However, such traditional assessment methods may fail to provide information about learning potential, learning procedures, learning functions, and mediation strategies that learners use while they are struggling to accomplish the lesson goals (Tzuriel, 2000). In parallel, the study of Waluyo (2019) revealed that the first-year Thai university students are typically at the basic CEFR levels (A1 and A2), equivalent to English proficiency levels of primary and junior high school students in the Thai education system. This highlights the urgent need for alternative assessment methods that do not overly rely on traditional approaches to merely assess the English proficiency of Thai learners. This is because learners' performance is not static, but it can keep improving and expanding. As such, traditional assessment has received a lot of criticisms in recent years, and the shortcomings of traditional assessment have thus led to the search for more effective assessment practices that not only determine learners' achievement but also shed some light on learners' learning process and progress. In this regard, dynamic assessment (henceforth DA) is proposed as an alternative assessment method that can compensate for what traditional assessment may lack (Derakhshan & Kordjazi, 2015; Naeini & Duvall, 2012; Siwathaworn & Wudthayagorn, 2018).

DA is defined as attempts to assess individuals' responsiveness to opportunities to learn new strategies and concepts (Feuerstein et al., 1979) or zone of proximal development (ZPD), defined by Vygotsky (Cole et al., 1978), which is the contrast between the level of what learners can do independently and the level of what they can do with the help of mediation (Poehner & Infante, 2016). DA is considered a promising alternative assessment method because it offers an individualized, culturally sensitive approach that assesses not just current abilities but also learning potential and progress over time. In particular, traditional DA refers to an assessment of how learners perceive, learn, think, and solve problems through an active teaching approach, which can be used to modify learners' cognitive functioning during testing and observe changes in their learning and problem-solving patterns (Kazemi et al., 2020). Besides traditional DA, DA that incorporates a computer-based testing approach has been developed to meet the ever-growing interest in computerized testing. One commonly used software in EFL and ESL studies for reading assessment is the computerized dynamic assessment (C-DA) (e.g., Lunrasri et al., 2022; Pishghadam & Barabadi, 2012; Pishghadam et al., 2011; Poehner & Lantolf, 2013; Teo, 2012; Zangoei et al., 2019).

C-DA refers to the use of computer technology to implement DA procedures. It is different from traditional DA in that computer technology is utilized to assess and analyze individual learners' cognitive functioning, learning strategies, and problem-solving skills. In other words, C-DA involves interactive and adaptive methods that traditional DA may not have. There are previous studies that have implemented a C-DA program to assess reading skills of tertiary-level learners. For example, Poehner et al. (2015) conducted a study in North American university Chinese language classes for non-native speakers, using C-DA to compare independent and mediated performances. They found improved scores with C-DA mediation. Additionally, Yang and Qian (2017) found significant improvement in English reading for first-year students in mainland China after four weeks of C-DA learning, concluding that C-DA influenced learning

growth. Finally, Hidri and Pileh Roud (2020) investigated C-DA's impact on upper-intermediate EFL Iranian learners, revealing significant test score improvement and differences between actual and mediated scores across various reading ability levels with different question types. Therefore, it could be seen that C-DA is a promising form of alternative assessment due to the use of computer technology to enhance DA procedures and the positive impact on learners' cognitive functioning across diverse contexts, in particular English reading comprehension of learners whose native language is not English. However, although there are numerous studies that have investigated the effectiveness of DA to assess different language skills of different levels of Thai learners, there is no study on C-DA that is used to promote reading comprehension undertaken in Thailand. Therefore, the purpose of the present study was to determine the effectiveness of the C-DA program on development of reading comprehension of Thai EFL undergraduate students, particularly those with a lower level of English proficiency, at a public university in the northern region of Thailand. The findings of this study would not only contribute to integrating and leveraging the technologies to DA to align with the purpose of assessment for learning but shed light on the significance of C-DA, highlighting the capabilities of mediational prompting to identify the development in reading comprehension within the ZPD of Thai EFL undergraduate students.

LITERATURE REVIEW

Computerized-Dynamic Assessment (C-DA)

The computerized test in this study was developed based on the concept of dynamic assessment (DA), which is grounded on Vygotsky's ZPD theory. Up to the present, DA proponents have developed and introduced a computerized testing approach based on the DA theory including computerized dynamic assessment (C-DA). In both ESL and EFL contexts, C-DA has attracted a lot of language educators' attention, and it has become a topic of many classroom-based studies regarding its effects on communicative skills including reading (e.g., Hidri & Pileh Roud, 2020; Yang & Qian, 2017, 2020). With regard to reading comprehension assessment, there has been a growing body of research on the implementation of C-DA in ESL and EFL scenarios at a tertiary level. Teo (2012), for example, has claimed that her DA software package could help students become better at understanding and regulating their own reading strategies. She gathered data before and after using the software, showing positive results both quantitatively and qualitatively through reflective portfolios. In addition to the usefulness of mediation, C-DA helps administer a large-scale study despite the smaller number of DA assessors and shortens the time demand of mediator-learner interactions. Furthermore, C-DA is efficient for large-scale studies with fewer assessors and less time needed for interactions. It can benefit learners who need frequent reassessment (Pishghadam et al., 2011; Poehner & Lantolf, 2013; Tzuriel & Shamir, 2002). C-DA also offers a learner profile that compares and analyzes data to diagnose a learner's current and potential development levels (Poehner, 2008) by examining actual scores, mediated scores, and learning potential scores (LPS). Above all, many studies have suggested using C-DA for ESL and EFL language testing where the computer could serve as the mediators instead of humans (Yang & Qian, 2017). However, some studies identified challenges associated with C-DA implementation in EFL reading comprehension. For example,

the study of Ismayana et al. (2020) mentioned issues such as the Internet instability affecting online-based C-DA tests and the time-consuming nature of developing a prototype assessment program based on C-DA. Besides, in the study of Pishghadam et al. (2011), a challenge was identified regarding preparation of mediational prompting, which was based on some guidelines of some reading books, rather than being tailored to address specific errors the students might encounter in the original non-dynamic test. This omission could affect the chances of working within the students' ZPD. These challenges suggest that although C-DA holds promise for assessing reading comprehension, it is important to carefully consider the context of online testing, address time and practicality constraints during research design and its implementation, as well as provide individualized support through mediation.

Approaches to C-DA

There are two approaches of DA: interactionist and interventionist (Lantolf & Poehner, 2004). These two approaches are distinguished by the purposes of the use of DA and the way in which mediation is given to examinees. In interactionist DA, the purpose is to promote language acquisition, and the mediation emerges from the interaction between the examiner and the examinees. On the other hand, the mediation in the interventionist DA is more formal and standardized as it involves quantifiable assistance with an aim to generate a weighted score. Concerning the application approaches to C-DA, the interventionist approach is more widely adopted than the interactionist (Haywood & Lidz, 2007; Hidri & Pileh Roud, 2020). As Yang and Qian (2017) have pointed out, in the interventionist approach, computers could serve as the mediators instead of humans since the mediation is flexible and negotiated in mediator-learner dialogues. They agree that C-DA therefore deems appropriate for the interventionist.

Mediators in C-DA

The program in C-DA produces prompts and hints to mediate learners' behavior and measure learners' abilities. The said mediator serves to gauge learners' ability to respond correctly to current implicit and future explicit mediations (Cho et al., 2020). In this way, C-DA uses a pre-determined prompt to uncover learners' ability (Bakhoda & Shabani, 2019a, 2019b). Put another way, when learners are unable to complete a task, the program in C-DA gradually provides prompts and/or hints in a gradual progression from implicit to explicit designs. Once learners complete the task successfully, a different version of the task is presented to determine whether they can transfer any of the learning to the new task. As a result, Poehner (2008), for one, has advocated C-DA since it can capture learners' ZPD by diagnosing their actual and potential levels of development generated by their responsiveness to mediation. As mediation in C-DA has a great impact on learners' levels of development in reading, designing an effective prompt or hint as a mediator is deemed crucial. In the research literature on interventionist approaches, a graduated prompt has been greatly recognized with regard to the notion of ZPD. Through the graduated prompt procedures, the amount and type of mediation required for learners to improve to a higher level of cognitive skills and effective learning can be measured. In terms of English reading skills, a growing number of studies have applied the mediational prompt to their C-DA intervention and reported on its advantages.

Interface design of C-DA

Fulcher (2003) formulates the basics of interface design for computer-based language testing, and his proposal has been adjusted to the development of the testing interfaces. His framework has been frequently cited in articles focusing on the development of computer-based language tests (e.g., Poonpon, 2021). As for interface design, his model is broken down into three main distinct phases as follows. The first phase focuses on incorporating best practices for navigation systems, metaphors, and presentation of test contents. The second phase consists of iterative testing and constant revision to ensure usability of the interface. Lastly, in the third phase, any necessary adjustments or fine-tuning to the interface are made based on larger-scale field testing. To develop the interface of C-DA, some studies have proposed user-friendly software to generate the program. For instance, Teo (2012) used *Viewlet Quiz 3* software to integrate mediation with assessment for her C-DA program to promote EFL learners' inferential reading skills, and Lunrasri (2020) made use of *iSpring Suite 9* to develop her C-DA to foster reading literacy of Thai ninth-grade students.

Limitations of C-DA

To advance knowledge in EFL and ESL studies, this review examines the limitations of C-DA in terms of the efficacy of computerized versus human-mediated interventions in DA that aligns with the core principles of sociocultural theory (SCT). According to Vygotsky's SCT, learning relies on social interaction between learners and the others; however, C-DA, which more widely adopted interventionist approach (Haywood & Lidz, 2007; Hidri & Pileh Roud, 2020), falls short in facilitating the same level of social interaction as human-mediated assessment (the approach of interactionist). C-DA is then often conducted through computer-mediated communication, which imposes limitations. Simply put, C-DA is limited in its ability to provide individualized feedback and support to learners. For example, Hidri and Pileh Roud (2020) found that in their interventionist procedures, the test-takers and mediators struggled to create shared understanding using the interventionist method. However, they noted that the human mediator still played a valuable role, as interactions between the mediator and the learner were adjusted to suit the learners' ZPD through dialogic interaction. Therefore, the researchers suggested customizing the prompting protocol according to each learner's abilities. Moreover, C-DA may not be able to fully capture the cultural and social context of the learners' language use as humans do. This limitation could result in an incomplete understanding of their language proficiency and communicative competence. To support, Estaji and Saeedian (2020) examined the effectiveness among human-only mediation, computer-only mediation, and mixture of both human and computer mediation on the EFL learners' reading comprehension. They found that the mixture of both human and computer mediation was more effective than human-only and computer-only mediations. However, there was no statistical difference between the human-only and computer-only mediation groups, indicating similar impacts on reading comprehension. The study highlighted the effectiveness of mediation provided through computers with the presence of a human mediator since humans are better at understanding emotions and motivations compared to computers, which is an important aspect of the sociocultural approach to assessment.

METHODOLOGY

Research design

This study provided insights into the development of a computerized reading test (CDRA) based on the DA theory, so some theoretical practices of Fulcher's (2003) interface model were adopted as criteria for CDRA development and a validation of the tool. In the work of Fulcher (2003), the model allows for the integration of technology in language assessment including the automated feedback mechanisms that enhance an experience of the computer-human interaction crucial to C-DA. This integration has rendered the said model a comprehensive approach to the assessment of language abilities. The study utilized a mixed-methods research design to elicit data regarding the effects of the developed CDRA program. The study followed the schematic representation of the test-train-test design proposed by Dörfler et al. (2009) where traditional static test was administered in a paper-and-pencil format (non-dynamically) to one group of students at the beginning (pre-test) and end (post-test) of the assessment procedure, while the CDRA program was provided during the intervention phase. This design is a reliable method for evaluating the students' reading comprehension performance by providing an unbiased estimate of the implementation of the CDRA program on new data that has not been used to train in the intervention phase. Additionally, a questionnaire and an interview protocol investigating the students' perspectives toward the CDRA program were used to further gather in-depth information from the students.

Research instruments

The development of the CDRA program involved the utilization of the reading comprehension tests in a paper-and-pencil format which included the pre-test, the post-test, and the blueprint of reading tests specifically designed for the CDRA program. Furthermore, to gather qualitative data, a questionnaire and a semi-structured interview protocol were used to explore the student participants' perspectives regarding the interface and utilization of the CDRA program. The three main phases of the study included the development of the test blueprints, the implementation of the CDRA program, and the evaluation of the CDRA program in which English reading tests and perspectives of the participating students toward the main intervention were looked into. Each phase is explained as follows.

Phase I: Planning and initial design

Stage 1: Stating test specification

In conjunction with the notion of English as an international language (EIL) which is considered a paradigm shift in Teaching English to Speakers of Other Languages (TESOL) and Second Language Acquisition (SLA) (McKay, 2018), the elements in developing the CDRA program should be based on its pedagogical principles and constructs. This is to ensure that assessments would be valid, reliable, and aligned with learning goals. According to McKay's (2018) principles, a great emphasis is placed on the local context and the development of strategic intercultural competence. Meanwhile, the EIL principles are applied with the notion of English language

assessment practices proposed by Rose and Syrbe (2018) addressing the implication of EIL for classroom-based assessment practice. In their perspective, assessment practices significantly influence English language instruction because English proficiency tests serve as gatekeepers for access into a range of social contexts where English is used as an international language. They add that these assessment practices have been received considerable attention from the EIL educators who are investigating whether these assessments adequately evaluate the students' strategic competence, intercultural communication, and ability to use English language in international contexts. As for the present study, EIL principles for classroom-based assessment practice were therefore taken into consideration for test design and test specification.

Step 1: Identifying participants

The study involved two groups of 30 first-year English students at a public university in northern Thailand, all of whom were enrolled in a compulsory reading course. The participants, aged 18 to 20, were assigned to the study in the first semester of 2022. According to an investigation of the participants' results of the standardized English tests (e.g., CU-TEP, IELTS, TOEFL, etc.) for the university admission, their English skills ranged from A2 to B1 according to the Common European Framework of Reference for Languages (CEFR), meeting the Ministry of Education's expectations for Thai high school graduates (The Ministry of Education, 2014, as cited in Ketamon et al., 2018). To ensure comparable reading comprehension, the Preliminary English Test (PET) was carried out. It is worth noting that the PET test is designed to correspond to the B1 level of the CEFR (University of Cambridge ESOL Examinations, 2009). From an initial pool of 54 students, 30 students were selected for the main study based on their PET results, following a selection criterion that aimed to achieve a homogeneous sample by including scores within one standard deviation of the mean. The study was approved by the Research Ethics Review Committee for Research Involving Human Subjects of Chulalongkorn University (COA No. 101/65), and the students gave informed consent before data collection commenced.

Step 2: Describing test constructs

Rose and Syrbe (2018) suggest that EIL test constructs should focus on strategic competence, intercultural communication, and ability to demonstrate accommodation skills. Thus, the constructs of the reading tests in this study incorporated the strategic competence in reading comprehension. Together, the test construct included more cognitively-demanding reading skills. As a result, the reading constructs that were measured in this study consisted of finding main ideas, identifying factual information, guessing word meaning, and drawing inferences. In terms of the measurement of vocabulary knowledge, the selection of the word corresponded to Level B1 or above according to the CEFR.

Step 3: Identifying the test format

The pre-test and post-test were used to determine if the CDRA program had any effects on the students' reading comprehension, while the blueprints of the reading test were developed for the CDRA program. A multiple-choice format was used to ensure consistency across different test administrations. It is also quickly administered and scored, making them efficient for

assessing many students' reading comprehension within a short time frame. Each test included two passages with four questions each, for a total of 16 items for four passages. The CDRA program included five reading passages for mediation sessions and a transfer task with items that were more challenging than the original DA tasks to assess students' ability to apply learned reading skills to new situations (Kamrood et al., 2018; Poehner, 2007). The pre- and post-tests offered four answer choices per question, while the CDRA's two-tiered testing procedure offered five choices, which enhanced the mediation process by assessing factual knowledge and reasoning behind choices, thus discouraging guessing. The tests were administered in a computer lab with Internet access, with 60 minutes to complete. In contrast, the first two CDRA reading tests had no time limit, allowing them the opportunity to familiarize themselves with the program, while the remaining tests and the transfer task adhered to a 60-minute limit.

Step 4: Selecting the texts

For the CDRA program reading tests (the four CDRA Tests), texts were selected for their relevance to EIL, following the recommendations of Elder and Davies (2006) and McKay (2018) to use contextually familiar material to reflect the students' shared backgrounds. Texts were selected from a variety of materials, including books and online content, which were screened for readability using the Gunning Fog Index to ensure they were appropriate for the target students. Birjandi and Naeni (2012) have proposed that the average Gunning Fog Index mark above 8 to 12 on the scale represents the approximate reading age of Grade 8 to high school senior of the native-English classroom, but anything above 12 marks of the scale is too hard for most people to read. In addition, Kaoropthai (2017) who developed a tailor-made multiple-choice diagnostic reading tests suggested that a text deemed appropriate for Grades 7-12 students (aged 12-18) in a native English classroom is also suitable for her first-year Thai university students, aged 18-20. For the transfer test, which was designed to assess the students' ability to apply knowledge to new problems, the most challenging texts were used, which according to Poehner (2008) were beyond the students' current abilities. In the selection process, discussions were held between researchers and coordinators focusing on culturally relevant topics such as Northern Thai cuisine and landmarks to ensure content relevance. When it comes to the presentation of the DA test tasks, they were arranged in accordance with difficulty levels—from the least to the most challenging ones.

Stage 2: Design of the CDRA program

Step 5: Designing the prototype

According to the literature review, *iSpring Suit*™ product has been suggested by a number of previous studies. This software is an online digital media that allows integration of mediation with assessment into a fully-featured interactive electronic test (Larissa et al., 2018; Wardhono et al., 2019). *iSpring Suite* is the software that can stand alone or support the function of another software, such as MS PowerPoint. Regarding its features, *iSpring Suite* is capable of not only storing the students' responses but also recording the number of incorrect responses and the mediators that are activated during the process. Additionally, it automatically sends

the scoring report to both the user and the instructor as a learner profile. To meet the needs of the researchers, the present study therefore utilized *iSpring Suit 10* to develop the CDRA program as the testing mode include an out-of-class delivery option, which enables the students to work at their own pace and in their own time. This can significantly enhance the students' attitudes toward the use and the effectiveness of the CDRA program when the alternative assessment is used in the reading classroom.

Step 6: Designing the scoring system

In this study, the score of one point was awarded for the correct answer to each question of the pre- and post-tests. As for the DA tests, the actual score was awarded on a 0-point scale for an incorrect answer at the first attempt. However, the format of a two-tier test was designated; that is, the first tier involved multiple-choice questions, and the second tier included a variety of test formats to justify the responses in the first tier. As for the responsiveness to mediators, the CDRA program calculated the score according to the number of attempts the student took and the score was deducted until the last prompt or hint was used (see Appendix A). It is noteworthy that the students were prohibited from submitting the tests in the CDRA program to the system should they fail to respond to or omit any item.

Step 7: Designing the interface of the mediational prompting

The mediation in the CDRA program was a fixed menu of standardized prompting. In this study, the mediating prompt or hint depicted five levels, moving from implicit to explicit designs and ending up with the correct answer. That is, the first and the fifth mediating prompts or hints could be fixed, whereas the format and composition of the other three prompts or hints varied from item to item depending on the reading constructs to be tested. In a gradual progression of the other levels, the prompts or hints were tailored to the reading construct (see Appendix B).

Stage 3: Validating tests and the CDRA program

The research instruments, including reading tests and the CDRA program, underwent validation by a panel of three experts. The experts ensured accuracy, clarity, and alignment with study objectives. All test items scored above the satisfactory cut-off of 0.5. Test blueprints were validated for accuracy and alignment, with an IOC index indicating favorable agreement. The CDRA program, including its interface and prompts, also received validation, showing consensus among experts. Subsequently, the program tests were administered to a pilot group.

Phase II: Usability testing

Stage 4: Pilot study and redesign

After piloting the CDRA program and conducting reading tests with 30 participants, all instruments were revised or redesigned to enhance their validity and reliability for the actual experiment. In terms of the CDRA program, its interface was adjusted in four key aspects, which are detailed as follows:

1) User profile interface

The interface of the CDRA program was designed in such a way that any devices (e.g., PC, smart phone, tablet, etc.) could run it easily, both online and offline. In terms of CDRA features, on the opening page of the program, the students needed to type their profile in the blank spaces (see Appendix C, Pictures 1-2). The next page of the software provided them with a description of the program and dynamic assessment. After reading the description, the students could then start the test. In addition, the text remained visible to the students while they were answering relevant test questions throughout the test time given. To navigate to the next or previous question or item, they could utilize the *Question List* located at the top left corner of the screen. This feature enabled them to move forward or go back to the previous page, while keeping the reading passage window visible. (see Appendix C, Picture 3).

2) Mediator moves protocol interface

The mediating prompts or hints were produced according to the cognitively-demanding reading skills—finding main idea, identifying factual information, guessing word meaning, and inferencing. There were four levels of mediation. The students were allowed to make four attempts at responding to each question. The maximum level of mediation each student received was four. The students were asked to select one correct answer from the choices given. If their first attempt was correct, the students gained a score of four for the item. If a second response was correct, a score of three was earned and so on until the correct answer was provided by the program and no points would be awarded. The computerized mediation ended automatically when the students found the correct answer to the question. Each time they answered a question incorrectly, the computerized mediational prompts or hints were also presented to them in order of increasing explicitness. The prompts or hints were arranged from the most implicit to the most explicit (see Appendix C, Pictures 4-8).

3) Scoring distribution and second-tier interface

For each test item, the CDRA program illustrated the actual score and the number of mediational prompts or hints the students used. The actual score was the score the students gained in their first attempt for each item, representing their independent performance without mediation. In response to this, five points were awarded once both the correct answer and the justification of the second tier were correct, whereas 0.5 point would be subtracted if the second tier was incorrect. In other words, only 4.5 points were awarded if the students chose the correct response but could not explicitly justify the answer (see Appendix C, Pictures 9-11). In terms of the mediated score, if the students gave a wrong answer to an item, the CDRA program provided them with prompts or hints until they got the right answer in the fifth prompt.

4) Scoring report interface

When the test was over, a scoring file would automatically be displayed on the screen. The CDRA program also had the capability to store the responses of the students and accurately track the number of incorrect responses, along with the mediation activated by each student

(see Appendix C, Pictures 12-14). Once the test was submitted, the scoring report was automatically sent to the students' email, while the researchers received the individual scores as part of a learner profile (see Appendix C, Picture 15).

As regards the reading tests, the researchers evaluated the validity, reliability and parallelism of the tests, as well as conducted an item analysis and assess the overall effectiveness of the CDRA program. The feedback led to software modifications that improved the usability of the tests. The analysis revealed that all item indices including difficulty, discrimination and point-biserial correlation, all of which met the recommended minimum score of .20, confirming the appropriateness of the tests. In terms of the KR-20, the score above .70 is generally considered to represent a reasonable level of internal consistency reliability and in this study the estimate of both tests turned out to be .73 and .71, respectively, suggesting that the tests were acceptable. With regard to the test blueprints for the CDRA program, the results indicated that the item difficulty index, discrimination index, point-biserial correlation, and KR-20 exhibited acceptable values. These values aligned with the recommended range mentioned earlier. Table 1 illustrates the results of the validation of the reading tests.

Table 1

Item analysis indices and reliability estimate for the pre-test and post-test and the test blueprints for the CDRA program

Description	Pre-test			Post-test			Test blueprints for the CDRA program														
							Delightful Dishes of Phayao (Test 1)			Phra Chao Ton Luang (Test 2)			Kwan Phayao (Test 3)			Sticky Rice (Test 4)			Transfer test		
	Min	Max	*M*	Min	Max	*M*	Min	Max	*M*	Min	Max	*M*	Min	Max	*M*	Min	Max	*M*	Min	Max	*M*
Difficulty index	.27	.83	.58	.53	.80	.64	.20	.68	.51	.23	.73	.55	.20	.80	.51	.40	.77	.59	.30	.67	.48
Discrimination index	.20	.80	.54	.20	.80	.50	.30	.70	.55	.37	.72	.58	.36	.75	.60	.42	.75	.63	.30	.80	.57
Point-biserial correlation (r_{pbs})	.22	.73	.65	.21	.69	.57	.28	.80	.62	.40	.84	.61	.48	.66	.59	.35	.68	.54	.30	.69	.54
Reliability estimate (KR-20)	-	-	.73	-	-	.71	-	-	.70	-	-	.72	-	-	.74	-	-	.71	-	-	.72

In addition, the parallelism between the pre- and post-tests was examined. The results of independent sample *t*-test between the mean scores of the pre-test (n = 15) and the post-test (n = 15) revealed that their variances were not different at the .05 significance level, indicating that there was no significant difference between the mean scores of the said tests. With regard to the effect size, Cohen's D test revealed that the effect size was large (Cohen's d = .79). All in all, the pre- and post-tests assessing reading comprehension were parallel.

Phase III: Fielding testing and fine tuning

Stage 5: Data analysis

Field testing was launched with the pilot group to make sure that all necessary arrangements in the CDRA program were made to collect, submit, score, distribute, retrieve, and provide feedback on the data. To this end, the software was estimated if it proved effective when it came to reading comprehension using a paired-samples *t*-test to compare if there was a significant difference between the pre-test and post-test mean scores at a significant level (p < .05). Furthermore, the students' perspectives regarding interface and utilization of the CDRA program were investigated with the use of the questionnaire and interview protocol. To

analyze the data in the questionnaire, descriptive statistics were used to report mean and standard deviations. Content analysis was also applied to the interview protocol, where the data obtained from the interview transcripts. The findings were presented as frequencies by quantifying occurrence of particular words or phrases within the transcripts.

Stage 6: The evaluation of the CDRA program

To determine the students' perspectives regarding the interface and use of the CDRA program, a questionnaire and a semi-structured interview protocol were used. The questionnaire comprised two sections. The first section which explored views regarding the program interface was adapted from Poonpon (2021) whose study was conducted at a Thai university, which is similar to the context of the target group of this present study, adding to the study's credibility and relevance. The questionnaire's second part, investigating attitudes toward program use, and the semi-structured interview protocol were adapted from the study of Shafiee et al. (2018) to align with the present study's objective. The aforementioned study was selected for its reliable questionnaire, which allowed for the elicitation of the participant views on DA use and the investigation of their learning abilities as well as performance improvement with mediation. Speaking of the semi-structured interview protocol, three questions were as follows: (1) Do you like the CDRA program? Why or Why not?, (2) Could you identify what you have gained or learned from using the CDRA program in assessing English reading comprehension, and (3) What are your suggestions on improving the CDRA program?. The questions were designed to elicit insights into the students' perceptions and feelings regarding the CDRA program, including the impact of the program on reading comprehension and suggestions for improvement. Validation of these instruments yielded an IOC index range of 0.6 to 1.0, indicating content validity. The reliability of the questionnaire, measured with a Cronbach's alpha of 0.84, confirmed its reliability.

FINDINGS

Effects of the CDRA on English reading comprehension of Thai EFL undergraduate students

Results of the pre-test and post-test

The mean scores of the pre- and post-tests were compared to determine whether there was a statistically significant difference in the students' performance before and after the use of the CDRA program as displayed in Table 2.

Table 2

Descriptive statistics and the paired-samples *t*-test of the pre-test and post-test scores

Reading test	*n*	*M*	*SD*	SE	95% CI		*t*	df	Sig. (2-tailed)
					Lower	Upper			
Pre-test	30	2.46	1.30	.33	-2.30	-.96	-4.99	29	.000***
Post-test	30	4.10	1.60						

M = Mean, SD = Standard Deviation, SE = Standard Error of the Mean, CI = Confidence Interval

***$p <$ .01

According to Table 2, a paired-samples t-test was performed to determine the effects of the CDRA program on the pre-test and post-test scores. The results indicated that there was a significant difference between the pre-test score (*M* = 2.46; *SD* = 1.30) and post-test score (*M* = 4.10; *SD* = 1.60), *t*(29) = -4.99, *p* = .00). As regards the effect size, Cohen's D test revealed that the effect size was large (Cohen's *d* = .91).

To determine the students' ZPDs, the analysis of their responsiveness in the mediational sessions should be conducted to make predictions about their ability (Poehner, 2005). With regard to the scores, in this study the CDRA program generated three types of scores which were actual scores, mediated scores, and Learning Potential Scores (LPS). The means and standard deviations for the reading scores gained from the CDRA program are presented in Table 3.

Table 3

Descriptive statistics for the CDRA scores (n = 30)

Variable	Actual Score		Mediated Score		Learning Potential Score (LPS)	
	M	*SD*	*M*	*SD*	*M*	*SD*
CDRA Test 1	7.27	5.20	14.97	2.29	1.13	.16
CDRA Test 2	6.77	3.50	15.20	1.86	1.18	.14
CDRA Test 3	11.43	3.10	16.70	1.74	1.10	.12
CDRA Test 4	13.70	3.27	17.70	1.81	1.09	.12
Transfer test	13.30	3.71	17.52	1.73	1.09	.10

In addition to the descriptive statistics of each score, the DA tests measured each student at five different time points. In this regard, a one-way repeated measures ANOVA was then employed to determine the mean scores from each test at different time periods. It was run with the five types of the reading tests as within-subject factors and the scores as the dependent variables. For the sake of brevity, the focus was on the results of the actual scores with the five types of reading test as a variable. The actual scores of the five tests were compared and the findings are presented in Table 4.

Table 4

Results of One-way Repeated Measures ANOVA of the actual scores (n = 30)

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	Partial Eta Squared (η^2)
Within Groups (Sphericity Assumed)	1300.29	4	325.07	23.55	.000	.45
Error (Sphericity Assumed)	1601.01	116	13.80			

The actual scores of the five reading tests in the CDRA program of the 30 students were compared. The sphericity assumption was tested using Mauchly's test, which indicated that the assumption had been met, $\chi^2(9) = 9.28$, $p = .412$. The results of the within-subject ANOVA in Table 4 showed that the actual scores were significantly different during at least one of the time points, $F(4, 116) = 23.55$, $p < .001$, partial $\eta^2 = .45$, with a medium effect size. In other words, there was a significant influence of test types on the actual scores. Additionally, Pairwise

Comparisons using the Bonferroni adjustment revealed the results of ten-pair comparisons between conditions.

As noted by Poehner et al. (2015), the C-DA aims to capture learners' ZPD. Similarly, one of the aims of the present study was to determine the students' actual and potential levels of development in reading comprehension. Generated by the CDRA program, the actual scores indicated the students' independent performance in reading comprehension, while the mediated scores identified their responsiveness to mediation, revealing their ZPDs which were the reading abilities that were not yet fully internalized but under construction to emerge. In particular, the relationship between the actual scores and the mediated scores as well as the relationship between the actual scores and the gain scores, which are calculated by subtracting the actual score from the mediated score, at each time point of the CDRA reading test administration were determined if the prompts in the CDRA program could result in changes in the students' reading comprehension. A Pearson Correlation Coefficient was computed to assess the linear relationship between the actual scores and mediated scores in the five time points after the reading tests had been administered through the CDRA program. The findings of the correlational analysis revealed that there were strong positive correlations between actual scores and mediated scores of the CDRA Test 1 (r = .79, p = .000), the CDRA Test 3 (r = .75, p = .000), the CDRA Test 4 (r = .77, p = .000), and the transfer test (r = .86, p = .000). The findings illustrated that the students with higher actual scores had higher mediated scores. Meanwhile, the correlational analysis between the actual scores and the gain scores was also estimated to investigate if the students had benefited from the mediation. The findings were that there were strongly negative correlations between actual scores and gain scores of the CDRA Test 1 (r = -.92, p = .000); the CDRA Test 2 (r = -.85, p = .000); the CDRA Test 3 (r = -.84, p = .000); the CDRA Test 4 (r = -.86, p = .000); and transfer test (r = -.90, p = .000). In short, the results indicated that the students with lower actual scores tended to experience more significant improvements through mediation compared to those with higher actual scores.

All in all, as is evident in Table 3, the results indicated that the development of actual scores differed sequentially across the reading tests used in the five mediations sessions. Furthermore, there were significant mean differences in ten pairs of scores between the CDRA Tests and the transfer test. Additionally, the findings of correlational analysis illustrated a strongly negative correlation between the actual scores and the gain scores, indicating that the students with low actual scores generally benefited from the CDRA program than those with higher ones. It may be argued that the students'reading comprehension had been considerably and progressively developed through the utilization of the CDRA program.

Findings from the questionnaire

To obtain valuable insights into the students' perspectives regarding the utilization and impact of the CDRA program on their reading comprehension, a questionnaire was administered. The results of the questionnaire were presented in Table 5.

Table 5

Results of the questionnaire on an investigation of the students' attitude toward the CDRA program (n = 30)

Item	Statement	Min	Max	*M*	*SD*	Interpretation
	Interface of the CDRA program					
1.	*Question List* helps me easily navigate and follow the direction of the reading test.	3	5	4.27	0.87	Agree
2.	The user profile interface was clear and appropriate.	3	5	4.10	0.80	Agree
3.	The process of test submission was easy and appropriate.	3	5	4.00	0.79	Agree
4.	The interface of reading text was appropriate.	2	5	4.03	0.67	Agree
5.	The screen layout of the CDRA program was appropriate.	2	5	4.10	0.71	Agree
6.	The prompting interface was clear and appropriate.	3	5	4.23	0.68	Agree
7.	The scoring interface was clear and appropriate.	3	5	4.07	0.64	Agree
	Grand mean score			4.11	0.74	Agree
	Use of the CDRA program					
8.	The mediational prompts provided by the CDRA program were beneficial to me.	2	5	4.33	0.66	Agree
9.	The mediational prompts during the tests stimulated me to activate my knowledge.	3	5	4.20	0.76	Agree
10.	The CDRA program helped improve my reading skills and reading strategies better.	2	5	4.30	0.70	Agree
11.	The interactive nature of the CDRA program by offering the mediational prompt was really helpful.	3	5	4.23	0.68	Agree
12.	I could get answers to my questions more easily through the CDRA program.	2	5	4.17	0.69	Agree
13.	Overall, I feel happy to have experienced the CDRA program.	2	5	4.37	0.81	Agree
	Grand mean score			4.27	0.72	Agree

According to Table 5, it was found that the overall mean scores of the questionnaire item were all higher than 4.00, producing a grand total mean score of the students' attitudes toward the CDRA program interface and its use of 4.11 (*SD* = 0.74) and 4.27 (*SD* = 0.72), respectively. The results of the first section demonstrated that the students expressed high levels of satisfaction with specific aspects of the interface design. Notably, they were highly satisfied with the *Question List* navigator, which facilitated easy test navigation (*M* = 4.27, *SD* = 0.87). Furthermore, they found the prompting interface (*M* = 4.23, *SD* = 0.68), user profile interface (*M* = 4.10, *SD* = 0.80), and screen layout (*M* = 4.10, *SD* = 0.71) to be clear, appropriate, and satisfactory. Besides, the students were satisfied with the scoring interface (*M* = 4.07, *SD* = 0.64), ranking it fifth among all statements. In response to the perspectives on the utilization of the CDRA program, the highest value came from the students' perceptions of the happiness they felt as a result of using it (*M* = 4.37, *SD* = 0.81).

Results of the semi-structured interview protocol

To further gain insights into the use of the CDRA program, semi-structured interviews were conducted. According to the analysis, the results displayed as frequencies by counting the occurrences of specific words or phrases in the interview transcripts. The results revealed that the focus was on three main aspects: advantages it offered, preference for it, and suggestions for further improvement.

Among the advantages mentioned, the most frequently cited was the introduction of a new method for English reading assessment (*f* = 10). When it came to the preference for the CDRA program interface, more than half of the students expressed a positive perspective regarding its interaction and presentation (*f* = 8). Regarding the interaction aspect, the students highlighted the usefulness and appropriateness of the *Question List* as a navigation tool that allowed for item review (*f* = 6). In terms of presentation, the students emphasized certain outstanding features of the controls that were clearly visible on the screen (*f* = 4). Interestingly, one student (*f* = 1) expressed a preference for having an instructor as a human mediator to assist in resolving issues along with the utilization of a computerized mediator, which was a benefit that, according to him, was absent in other computer-based tests. With regard to suggestions for improvement, two students (*f* = 2) proposed that the CDRA program should be conducted outside of regular class hours, citing fatigue from the lessons as a factor. As suggested, this would eliminate the possibility that time constraint would affect the students' test performance. Nevertheless, a majority of them agreed that the CDRA program was satisfactory in terms of its interface and functions (*f* = 7).

DISCUSSION

The study found that the CDRA program positively impacted the students' reading comprehension, as evidenced by improved post-test scores. Questionnaire responses and interviews further supported the conclusion that the students held positive perspectives regarding the CDRA program's impact on their reading comprehension. Such findings were consistent with prior studies focusing on the development of C-DA to measure reading skills of the university students (e.g., Ebadi & Saeedian, 2015; Ebadi & Saeedian, 2016a, 2016b; Hidri & Pileh Roud, 2020; Poehner & Lantolf, 2013; Teo, 2012, 2014; Yang & Qian, 2017, 2020) which reported that the results of the quantitative data revealed that the students made significant progress through the intervention with the C-DA as their post-test scores were higher than the pre-test scores. For example, Hidri and Pileh Roud (2020) confirmed that C-DA had significantly positive impacts on improving the students' three types of test scores including actual, mediated, and learning potential scores with statistically significant differences between actual and mediated scores with various reading ability levels in using hints in the question type. Moreover, the findings of a study conducted by Ebadi and Saeedian (2016a) further confirmed the value of C-DA procedure that provided in-depth information about various learning needs of the students who had the same standard performance scores.

In this study, one of the plausible reasons why the CDRA yielded a favorable result was the use of graduated prompting. While using the software, comprehension questions were asked with the use of prompts or hints which helped the students answer the questions they were asked in the reading test. The CDRA program gradually provided prompts or hints in the form of instructions or guidelines that helped them find out the correct answers. According to the mediational sessions, an integration of instruction and assessment could be feasible via the software attributed to the effective pre-scripted prompting. When developing prompting in this study, the comprehension questions were devised through the prompts and hints which were gradually constructed from implicit to explicit design, and they served as a gauge of the

students' ability to respond to the reading questions. This is consistent with Vygotsky's notion in that an effective mediation serving as the medium of learning needs to be systematically organized and rendered following the principle of moving from implicit to explicit (Gal'perin, 1992; Lantolf & Thorne, 2006; Vygotsky, 1962). Through the mediational process, when the students were unable to complete a reading test item, the CDRA program gradually provided prompts and hints by giving instruction or providing guidelines that helped them find out the correct answer. Simply put, in this study, the mediation in the CDRA program used pre-determined prompts and hints to unveil the students' in-depth ability to read for comprehension. Given the fact that the CDRA program is different from traditional assessment, it could be stated that mediational prompting in the CDRA program promoted the students' learning as it guided them to effectively utilize their cognitive skills (Hidri, 2014). Accordingly, the prompting protocol in the CDRA program helped the students achieve their learning goal which is apparently coherent with the notion of ZPD in that prompts or hints provided them with the right level of support and guidance in English reading comprehension to bridge the gap between their current reading abilities and their potential development in English reading comprehension performance. By understanding and utilizing the ZPD concept, the researchers could provide additional support like remedial courses to meet the individual needs of the students for their future improvement in English reading comprehension. The findings of the present study are in line with Veerbeek et al. (2019) that the electronically delivering mediation not only contained explanations or feedback regarding the correctness of answers to enhance the students' ZPD, but it also included training beyond repeated instruction, thus yielding greater insight into their potential development whereas the traditional tests do not or cannot. Similarly, a study carried out by Zhang et al. (2017) on prompts in computerized testing in the students' cognitive skills has reported that the graduated prompt approach in C-DA aided the students in problem-solving by offering repeated practice with increasingly specific hints, facilitating their discovery and application of principles to solve problems and enhancing their learning.

However, Hidri and Pileh Roud (2020) have reported a contradictory findings when they mentioned that some test-takers did not benefit from pre-determined prompting. This is because their study merely used the DA intervention approach in C-DA; as a results, the researchers could not determine how much mediational prompt test-takers needed for different reading question types. It was thus hard to accurately determine if the mediation chosen by the test-takers effectively addressed their ZAD and ZPD. This could be explained that the test-takers and mediators in their interventionist procedures were unable to co-construct meaning through the interventionist approach. Unlike the interactionist DA, they added for further research that the human mediator was still helpful as mediator-learner interactions were fine-tuned to learners' ZPD through dialogic interaction. The researchers thus recommended tailoring the prompting protocol based on individual test-takers' ability. As such, it is suggested that the presence of a human mediator is needed even when a computerized mediation is used as it increases the possibility of working within individual learners' ZPD (Modarresi & Alavi, 2014). For these discrepancies between this study's findings and those of Hidri and Pileh Roud's (2020), the present study was conducive to a comprehensive diagnosis of the students' reading comprehension performance in their ZAD and ZPD as shown in significant correlations due to the intervention of human-mediator throughout DA procedure, yielding positive results based

on the interview findings. Also, the findings of the correlational analysis in this study illustrated that the students with low actual scores gained advantages from the mediation which are in line with other previous studies such as Kamrood et al. (2019), Poehner et al. (2015), and Yang and Qian (2017).

Another reason why the CDRA program worked may have stemmed from an inclusion of the transfer test task. The uniqueness of graduated prompting lies in the concept of "transfer," which refers to learners' ability to retain what they had previously learned (Poehner, 2008) and their ability to transform learning into a new context or "transcendence" (Shrestha, 2017). In this study, the transfer test in which the task focused on the same reading constructs targeted in the CDRA program but presented more challenging tasks was used to determine the extent to which students could adapt what they had learned through the previous DA sessions to handle more challenging tasks (Poehner et al., 2015). In the transfer test, this study used the less familiarity of content in reading texts and a higher Fox index as criteria of the difficulty of reading texts. In this light, after the students received the initial support through DA sessions, their development in reading comprehension was progressively addressed through their engagement with interactive procedures, unveiling certain emergent functions which had not been yet fully internalized or had not been incorporated into the zone of actual development (Kozulin & Garb, 2002). After that, the transfer test task that required the transcendence of students' previous learning was given. At this point, the students with successful performance on the transfer task could produce long-term effects that resulted in higher levels of thinking (Feuerstein et al., 1979). The students' reading abilities could be regarded as internalized as indicated by the mean scores of the transfer test, which exceeded those of the CDRA Tests 1 to 3 presented in Table 3. Together, the findings revealed the significant differences in the mean of actual scores between the CDRA Test tasks and the transfer task with strong positive correlations between actual scores and mediated scores, indicating that the students experienced advantages from the intervention, resulting in their reading performance in the post-test which outperformed that of the pre-test. These findings were in line with a number of previous C-DA studies such as Kamrood et al. (2019), Poehner et al. (2015), and Yang and Qian (2017). In addition, one study worth mentioning was undertaken by Ebadi and Saeedian (2016a) who employed various transfer tests, with varying levels of prompts and hints provided, ranging from reduced assistance to no assistance at all. The findings were positive, indicating that their learners demonstrated improved reading skills. Moreover, almost all learners showed signs of development, and none regressed during the transfer test sessions.

With all the reasons mentioned earlier, it could be concluded that in the present study the students had positive perspectives of utilization of the CDRA program in diagnosing their reading comprehension. The findings from the questionnaire and semi-structured interview protocol indicated that the students enthusiastically embraced the CDRA program, and they believed that it was beneficial in enhancing their reading comprehension. Some also admitted that the computerized test based on DA offered them a new classroom-based assessment method where instruction and assessment were combined into a single activity. There were different reasons why these students developed positive perspectives about the CDRA program, which could be explained as follows.

First, the students believed that the CDRA program helped improve their reading skills and reading strategies better owing to the usefulness of the graduated prompting that stimulated them to activate their knowledge, enabled them to gain new knowledge of English words, instructed them how to find the main idea, and enabled them to draw an inference. Regarding this matter, the CDRA program assisted the students to be able to identify the main idea of a text through the graduated prompt protocol. The prompts in such a design were found in the measurement of the students' reading ability in drawing inferences by stating "Prompt 2: Identify the *main idea* of the text," and "Prompt 3: Find the choice in which the said *main idea* is expressed." It is apparent that the students' reading comprehension was promoted owing to the prompting protocol which encompassed the strategic reading, in line with a study done by Teo (2012) revealing the changes in the students' characteristics regarding reading ability after going through certain tasks in the C-DA program by indicating that computerized mediated assistance made the students more aware of their metacognition and helped them actively control their reading process.

Additionally, the students found the CDRA program to be suitable and easy to use, expressing satisfaction with its various functions and interfaces of this computerized reading test, such as the *Question List* navigator, user profile interface for login, screen layout, prompting interface, and scoring interface, among others. Similar to the finding from the first section of the questionnaire and interview protocol, the students liked the interaction offered by the CDRA program, particularly in terms of navigation, as it facilitated their comprehension and made it easy for them to follow the directions of the computerized test. This also indicated that the design of the CDRA program, following Fulcher's (2003) recommendations, was relatively effective, as it did not generate negative feedback from the student participants. The findings also suggested that the reading tests used in this study were valid as the interface did not affect the accurate determination of valid test scores (Fulcher, 2003). Besides, the students demonstrated a strong preference for various elements of the developed CDRA program, encompassing graphic elements and typographical elements. As suggested by Weinerth et al. (2014), if the design of the computer-based assessment is not good, it can distract the students' attention, leading to distorted assessment results. Adding to this, Poonpon (2021) suggested that the test interface and test platform should be user-friendly.

Lastly, along the use of the CDRA program, the students noticed improved reading comprehension, and their actual scores went gradually higher. Simultaneously, their perspectives became more positive as they recognized the usefulness of the interactive prompting protocol in the software. They found the graduated prompting in the CDRA program helpful, aligning with the report of their feedbacks toward C-DA in the study of Yang and Qian (2017) where their students described the experience as a "happy feeling of gains" (p. 13). According to the report, the protocol allowed them to choose new answers, provided them with needed explanations, guided them to locate key information, and highlighted reasons for reading mistakes. Furthermore, the students preferred the CDRA program owing to the interface where the presentation of the reading test looked appropriate. As a result, a very high level of the overall students' perspectives regarding the helpfulness of the CDRA program was reported in the findings section. As Shabani (2012b) has pointed out, computer-based testing can direct learners' attention to the key sections of the reading text and assist them to when they are striving to

understand the text better. However, this finding was contrary to a previous study carried out by Yang and Qian (2017) as a few students did not believe in the usefulness of the C-DA in improving their reading ability. These students were opposed to it due to certain limitations in the intervention's functionality, which restricted them from previewing the questions before reading the passage. As a result, they felt that this hindered their ability to complete the task efficiently. Their sense of opposition seemed to be closely related to a link between attitudes toward DA and their language proficiency (Taheri & Vahid Dastjerdi, 2016); that is, high language proficiency students may oppose DA, whereas those with low proficiency may support it. To support, Tzuriel (2003) has noted that the learners with higher proficiency tend to show less favorable attitudes toward DA, attributing it to their high level of self-confidence. Poehner (2008) subsequently suggested that the high-proficiency learners might exhibit lower responsiveness to DA. In fact, the relationship between the students' English proficiency and their perspectives on language assessment methods is complex and multifaceted. This correlation may exhibit as varying degrees of resistance and acceptance, illustrated by how the students with lower proficiency levels may be more accepting of C-DA as beneficial tools for language improvement, while those with higher proficiency levels may resist C-DA, perceiving it as less beneficial.

Given this inverse relationship, it is crucial to introduce the CDRA program especially to the students with lower English proficiency levels, as demonstrated by positive outcomes in other DA studies across different language contexts such as Klungthong and Wasanasomsithi (2024), Lunrasri et al. (2022), Siwathaworn and Wudthayagorn (2018), and Wang and Chen (2016). Such insights into effectiveness of the developed software could significantly impact the students' language proficiency development and academic achievements.

When discussing the reasons behind the positive outcomes of effective intervention and examining the students' positive views on the CDRA program, it is important to evaluate challenges and pinpoint potential areas for improvement. The questionnaire's results indicated that the students believed that the CDRA program helped improve their reading skills and reading strategies significantly (M = 4.30, SD = 0.70), aligning with previous studies in DA and C-DA EFL/ESL reading such as Nazari and Mansouri (2014), Shabani (2012a), Teo (2012), and Teo (2014). Noted by Teo (2012), the mediation process in C-DA enhanced the students' cognitive and metacognitive reading strategies, such as identifying main ideas, using contextual hints, and making inferences. Moreover, Zadkhast et al. (2023) found that concurrent group dynamic assessment (GDA) outperformed cumulative GDA in cultivating higher-level cognitive functions and metacognitive reading strategies. The authors explained the reasons that unpredictability of mediation shifts in concurrent GDA heightened the students' awareness, attention, and engagement, prompting the use of their higher-level cognitive functions like making inferences, recalling new information in reading, to name a few. Conversely, cumulative GDA could lead to distraction and impede the development of these cognitive skills due to the more passive role of secondary interactants. Speaking of the present study, although the mediators in the CDRA program were developed to elicit the students' cognitively-demanding reading skills, there may be opportunities to dig deeper into the specific strategies employed by those with low actual scores, particularly through the mediational prompting. However, the scarcity of such in-depth implementation had arisen due to various causes such as time

constraints during data collection, the limited number of human mediators, and affective factors in the individual students such as their fatigue or their ability to deal with multitasking (e.g., doing the reading test on the software while elaborating on their reading strategies). In terms of the potential areas for improvement, these challenges could potentially be addressed by allocating ample time for data collection process and implementing effective tools to investigate the students' reading strategies used during testing procedures.

IMPLICATIONS

There are several implications for instructors and educators who aim to develop and utilize the C-DA to measure EFL undergraduate students' reading comprehension. Firstly, this study revealed that graduated prompting in the CDRA program assisted the students' ability to gradually respond to the reading questions resulting in the development of reading strategies and improvement in reading comprehension. This is because the graduated prompting was used as the mediation to help the students learn reading strategies and find the correct answers during the mediational procedure. Therefore, if the C-DA is developed to test reading, test designers should work out the prompts that are sensitive to students' ZPD. They need to make sure that the graduated prompting contains the comprehensive and instructional description that is presented in a gradually implicit to explicit design. Also, the design of the prompts should enable students to transfer what they have learned to other reading questions by detecting similarities of the reading strategies between questions.

Secondly, the CDRA program became the students' new and favorable experience in EFL reading assessment method that helped diagnose their reading comprehension where the students were interacted with and mediated both electronic devices and human-beings. It is noted that the study was conducted in a computer lab where the human mediator was integrated into the CDRA program. However, utilizing the CDRA program alone would not ultimately enhance students' learning. Therefore, teachers who wish to implement the CDRA program need to be well aware of the role they will have to play to ensure the success of the implementation. In addition, students with different ZPDs required customized mediators to reflect their individual needs. Consequently, during the C-DA procedures, the teacher should closely observe students' performances so that necessary assistance can be provided when problems arise. The human mediator should, for example, identify any difficulties students may encounter if the CDRA program does not give enough clues to the answer and further elaboration is needed. In so doing, immediate feedback from the teacher could help students continue performing the task. As the role of a mediator is vital for successfully implementing the CDRA, the teachers should undergo necessary training including how to implement the CDRA program, how to provide supportive steps, and how to guide students to the next level of functioning.

LIMITATIONS

One limitation of the present study that should be acknowledged is the time allocated for the reading tests in the CDRA program. In this study, the students faced time constraints when the

CDRA program was administered immediately after the main instruction which had lasted three hours. As a result, they did not pay as much attention to the CDRA program as they should have, owing to either fatigue or a lack of understanding of the significance of the CDRA program. Thus, data collected in this study may not have accurately reflected the effectiveness of the program. Also, as the students required some technology literacy to successfully perform the test tasks in the CDRA program, but as the researchers did not assess their level of technology literacy before the study commenced, the data collected from them might not have accurately shed light on how the students could fully benefit from the CDRA program.

RECOMMENDATIONS FOR FURTHER RESEARCH

Based on the study findings, the following recommendations could be made:

1. Future research should be conducted to determine the effectiveness of computerized dynamic assessment which encompasses a broader range of test constructions and test types such as open-ended tests to elicit a more holistic view of students' reading comprehension.

2. Qualitative research should be carried out to shed more light on higher-order cognitive and analytical skills of students after they have been exposed to computerized dynamic assessment.

3. Research should also be undertaken to explore and monitor students' responsiveness to mediation through qualitative tools such as learning logs, one-to-one interviews, and think-aloud protocols as these methods can help capture deeper insights into students' decision-making processes when selecting prompts.

4. Longitudinal studies should be conducted to investigate whether the effects of the CDRA program on the English reading comprehension of undergraduate students, particularly those with low English proficiency, can be sustained over time.

CONCLUSION

The CDRA program has proved to be an effective assessment tool to assess reading comprehension of undergraduate students. From a pedagogical standpoint, the present study highlights the development process of a computerized dynamic assessment (C-DA) program following the framework of Fulcher (2003), incorporating design elements such as user experience and mediation strategies based on the concept of Vygotsky's (Cole et al., 1978) zone of proximal development (ZPD). Besides, the software developed in the present study had the capability to provide mediation, catered to a vast number of students, and automatically generated reports regarding their performance in reading comprehension. Therefore, the CDRA program is a ready-made innovation that can be utilized alongside traditional classroom-based assessments. In other words, the C-DA program could be developed and extensively utilized in language classroom-based assessments, regardless of the levels of language learning and English

proficiency of learners. As for the concept of integrating assessment into instruction to promote learning, the C-DA program offers support to instructors as it creates a learning environment centered around assessment, yielding more evidence of the students' learning progress in addition to summative assessment regularly used. By incorporating the C-DA program's interface design and prompting approach, the instructors can enhance their classroom instruction in various language domains, as evidenced by the gain scores in this study. The students also had a positive attitude toward the CDRA program interface, acknowledged their preferences, and provided suggestions for further improvement of the software. For these reasons, the CDRA program can be beneficial in language classrooms as it supports language development of the students, particularly those with a lower level of English proficiency, while bridging the gap between reading instruction and reading assessment unlike others.

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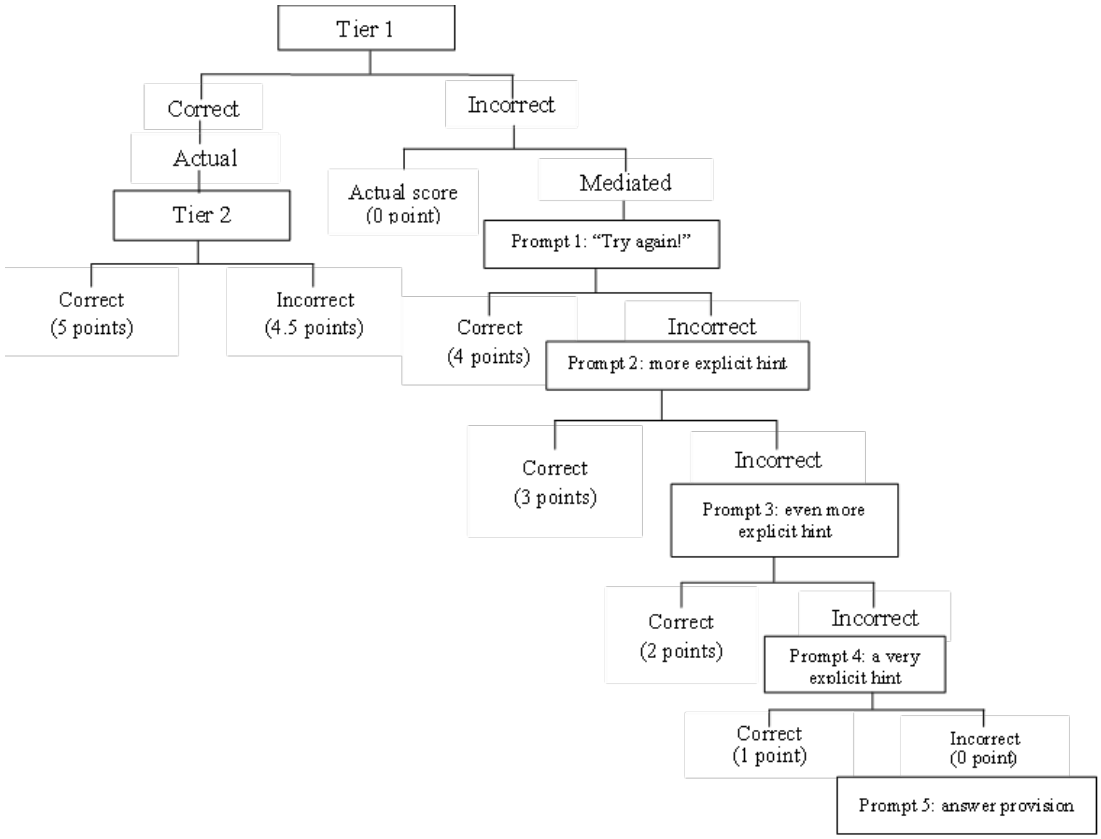
Appendix A

A flowchart for the scoring of the CDRA program



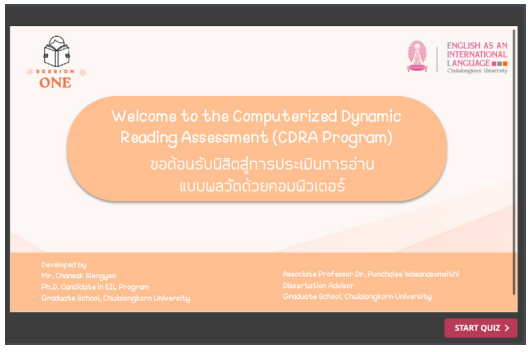
Appendix B

The levels of explicitness of the mediation move in each reading skills (Adapted from Birjandi & Naeni (2012))

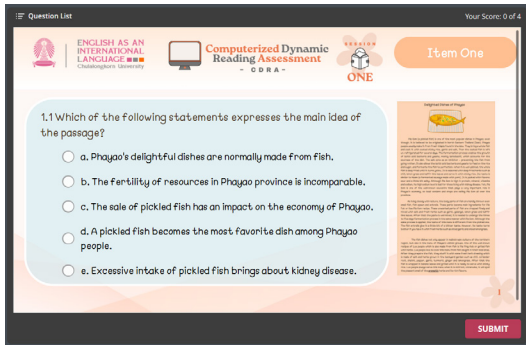
Reading Skill	The Mediation Move	
	Prompt/ Hint	Levels of Explicitness
Finding main idea	1	Sorry, the answer is wrong. Please try it again.
	2	Find the topic of the text (The most frequent seen word).
	3	Find the main idea of the XXX paragraph (e.g., first paragraph).
	4	Check whether the idea is supported by the whole paragraph not just one paragraph.
	5	The right answer is …. The reason is that ….
Identifying factual information	1	Sorry, the answer is wrong. Please try it again.
	2	Scan the paragraph specified to find the word and take note.
	3	Eliminate the choices based on the information noted.
	4	Check the certain sentence, phrase, or a word given to find the information you are looking up.
	5	The right answer is …. The reason is that ….
Guessing word meaning	1	Sorry, the answer is wrong. Please try it again.
	2	*(Word with affixes)* Analyze the word for affixes. *(Word with no affixes)* Check the meaning of the affix in that word.
	3	Look for a key word.
	4	Check each choice with the passage or the referred paragraph
	5	The right answer is …. The reason is that ….
Drawing inferences	1	Sorry, the answer is wrong. Please try it again.
	2	Identify the main idea of the text.
	3	Find the choice in which the said main idea is expressed.
	4	Check the idea of each option by looking for the key words' synonyms or antonyms in order to delete the irrelevant or incorrect choice).
	5	The right answer is …. The reason is that ….

Appendix C

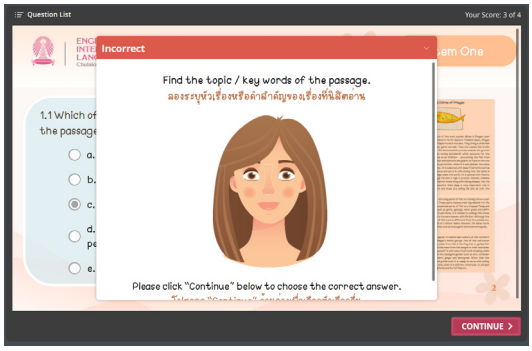
Pictures of the interface of the computerized dynamic reading assessment program

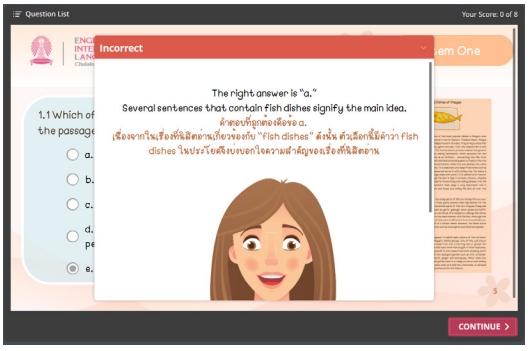


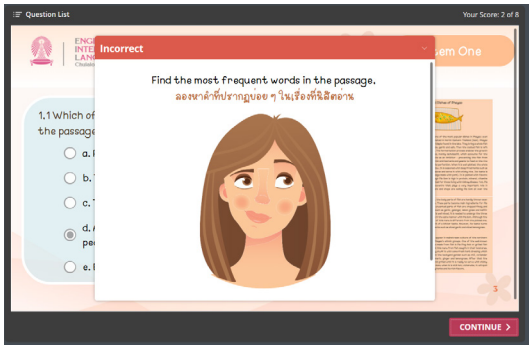
Pictures 1-2 *User profile interface*

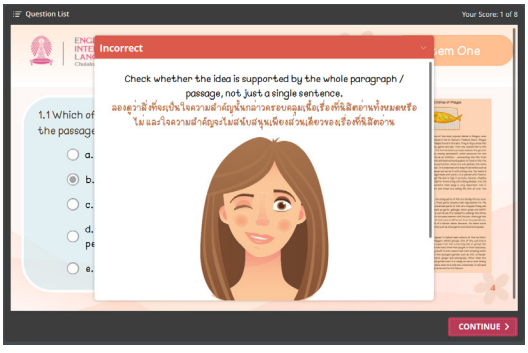


Picture 3 *Example of reading test task with the reading text*



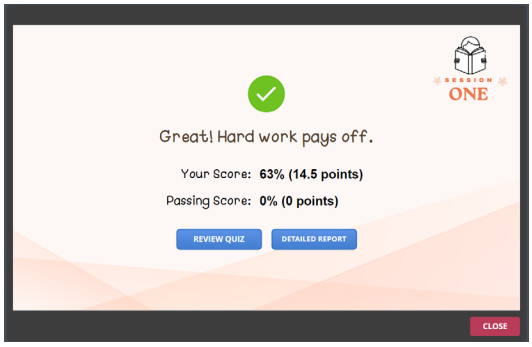


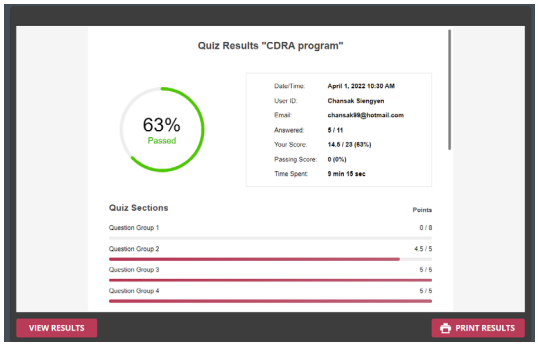


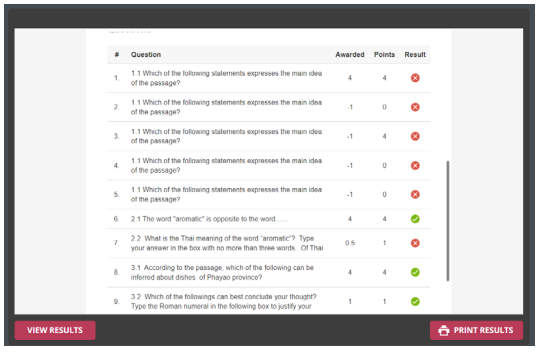


Pictures 4-8 *Examples of the mediational prompts or hints according to each explicitness*

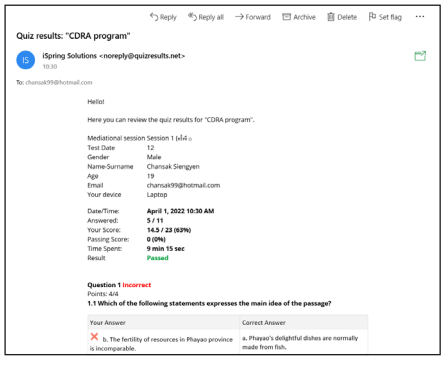
Pictures 9-11 *Example of the second-tier item with the feedback*







Pictures 12-14 *Scoring report interface*



Picture 15 *Scoring report via test-taker's email*