Assistive Technology for Enhancing Saudi Female Undergraduate Students' Reading Cognitive Abilities: An Investigation of Reading Models and Their Impacts on Reading Performance

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Abstract—This study examines the effects of assistive technology, specifically text-to speech (TTS) technology on enhancing Saudi EFL students' reading cognitive abilities. The study utilized text to speech Natural Reader by Natural Soft Ltd (2022) to carry out a pretest-posttest quasi experiment, to measure students' reading scores before and after the treatment. Instruments also include two questionnaires. 49 students, enrolled in level III reading course of the English Department at the College of Languages and Translation, at Imam Mohammed Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia, participated in the present study. The experiment lasted 12 weeks during the first semester of the year 2022-2023. The first questionnaire results showed that 66.7% of the students face problems in reading, with 43.8% having problems with loud reading, and 31.3% of students read less than 100 words per minute. The results also showed that 40.81% face problems related to pronunciation, vocabulary, and reading comprehension. The total score of the pre-test and posttest are in favor of posttest with mean score of (74.73 ±10.65) compared to (41.48 ±7.94) for pre-test. The findings reveal that there is an effect of assistive technology on students' reading cognitive abilities related to reading speed, comprehension, vocabulary, and critical thinking, affirming students' strong satisfaction with the Reader software, reaching the percentage of 87.5%. The study recommends using the technology-based reading model, proposed by the researcher, in the reading courses at Saudi universities, and investigating the linguistic changes that students experience due to the use of assistive technology in EFL.

Index Terms—assistive technology, cognitive abilities, reading models, reading performance, text-to-speech

I. INTRODUCTION

The challenges that students face in reading hinder their abilities to master English as a foreign language since reading affects their abilities to understand different types of texts, and interact with their contents. Reading affects students' abilities to express their ideas, and develop their speaking, listening, and writing skills. Basarab et al. (2013) identified some reading comprehension obstacles including inability to understand the author's core message, and inability to provide critical and inferential evidence of the issues that reading texts deal with. Al-Jarrah and Ismail (2018) identified difficulties contribute to fluency, comprehension, and retention. Durukan (2020) found problems related to reading training speed and its impact on comprehension skills (pp. 184-185). Al Roomy (2022) investigated how lack of critical reading has negative impacts on students' overall reading skills. Furthermore, research explored the effects of assistive technology, including text -to speech software (TTS) on students' cognitive interactions. For example, Silvestri et al. (2022) indicated that TTS helped students to improve their cognitive competencies that impact reading comprehension, which include fluency, critical analysis, mental lexicon, and phonological process, which helped students to understand various texts at lexical, syntactical, semantic, and pragmatic levels. Schmitt et al. (2019) indicated that there is a statistically significant effect of assistive technology on improving students' reading performance, within three measures, highlighting reading comprehension, vocabulary, and silent reading efficiency. Bonifacci et al. (2022) showed that assistive technology, specifically, TTS helped struggling readers who face challenges to decode the text through improving pronunciation and word identification. Staels and van den Broeck (2015) asserted that TTS can provide scaffolding to reduce the burden of decoding the text, and which can motivate students to acquire cognitive resources to help them improve their reading speed, fluency, and comprehension (pp. 448-450). Therefore, the current study aims to examine the problems that Saudi female undergraduate students face while studying reading as an essential course in their study of EFL. The current study investigated the feasibility of using TTS as a means to help students improve their reading cognitive abilities. The study utilized Natural Reader Edu by Natural Soft Ltd (2022), which has been used by a number of universities in USA and Canada. The specific problem that this

research tackles is that teachers at the College of Languages and Translation, Imam Mohammed Ibn Saud Islamic University (IMSIU) complain that students' reading final exam scores are low, reflecting that students face difficulties in reading skills, including detecting comprehension knowledge from the texts, identifying main ideas, applying critical and analytical thinking, understanding word meanings, building new vocabulary, and improving reading speed. The final exam results also showed weakness in summarizing main ideas, understanding referential meanings, interpreting figurative language and implied meanings, and reconstructing new meanings when answering the comprehension questions. As such, the current study aims to examine the impact of assistive technology, specifically text-to speech (TTS) technology on Saudi female undergraduate students' reading cognitive abilities, and consequently reading performance. This study investigated the extent to which TTS can affect students' performance in reading, and how technology can help students to improve their cognitive abilities and skills, in terms of carrying out the mental tasks associated with reading, including understanding details and sequences of events, interpreting implied and inferential meanings, expressing new perspectives on the reading texts, storing and retrieving of information, building new vocabulary, and summarizing main ideas. Since there is a relationship between cognitive abilities and reading skills (Abusamra et al., 2020; Al Roomy, 2022; Alshammari, 2022; Mohseni et al., 2020; Reza et al., 2013), the study examined the extent to which assistive technology would help students to improve their perception in recognizing the words and their meanings from the reading texts, enhance their attention and abilities to sustain concentration on a particular piece of information, and improve their working memory to identify and manipulate the ideas of the texts so as to make sound decisions to solve any problems while they read.

II. LITERATURE REVIEW

A. Reading Theories and Models

Theories and models of reading have been developed over the past decades to provide EFL learners with effective tools to improve reading skills. Research (Abu Baha, 2017; Atkinson et al., 2017; Wilhelm et al., 2001; Witte & Cherry, 1994) examined a number of models and revealed that the read-aloud model has been used to help learner access information from short-term memory. Using this model, students can verbalize their thoughts, and express their comprehension of the texts while they read. Another model is the transmissional model which directs students to read for specific information in order to use it to answer comprehension questions. The third model is the transactional reading, which guides students to know that the meaning of the texts does not exist only in the text, but it also requires an interaction between the text and the reader. Therefore, in the transmissional model of reading, students share the knowledge they learn from the reading texts, while in the transactional model, students become active meaning makers based on their lived experiences (Kim, 2020). A fourth model is the bottom-up reading model, which focuses on the phonetic and phonological aspects of the text. A fifth model is the top-down reading model, or the concept-driven model, which emphasizes the contents of the text. Research also indicated that teachers use different approaches to teach reading in the EFL classrooms, including behaviorism, cognitivism, sociocultural structuralism, and the schema theory. While the behaviorist theory depends on providing students with stimuli to motivate them to respond to the reading process, the cognitivist approach guides students to think critically, summarize the information, ask questions, and interpret inferential meanings (Sutherland & Incera, 2021). In other words, the cognitive structuralist model is used to help students to focus on the purpose of reading, using their cognitive skills of perception, attention, analysis, and evaluation to identify main ideas, recognize and recall specific details, follow the sequence of events and illustration, and draw conclusions from the arguments. The schema theory is based on using learners' past experiences to create mental frameworks that help them make sense of new experiences (Anderson, 1994, pp. 469–482). Using the schema model, students can understand the message of the text and create a mental system that helps them to put together all the detailed information, the descriptions, and the events that are involved in developing the message of the text. Another theory, which is used in reading, is information processing theory, which shows readers how information is grasped in order to be able to store and retrieve what they read (Kmetz, 2020). While there are different models of information processing, including Atkinson and Shiffrin (1977, 2017), and Baddeley and Hitch's (2019), they are all based on helping students to enhance their memories to perceive, store, and retrieved information. While Atkinson and Shiffrin's model focuses on enhancing sensory memory, short-term memory, and long term-memory, Baddeley and Hitch's model works on phonological information, articulatory rehearsal process, visual spatial information, and episodic information.

B. Students' Reading Problems and Solutions

Previous research (Al-Jarrah & Ismail, 2018; Al-Qahtani, 2016; Martins & Capellini, 2021) investigated the problems that EFL students face when developing their reading performance, including difficulties in reading comprehension, loud reading and reading speed, understanding details and inferential meanings, and lack of vocabulary skills, all of which affect their reading fluency. In another study, Baddeley and Hitch (2019) concluded that phonological problems affect reading fluency when students are unable to differentiate the features of different sounds. Many students struggle in understanding the text and responding to comprehension questions because of difficulties in pronunciation, sound recognition, and silent sounds (Abusamra et al., 2020). In general, EFL students struggle with linguistic processing, from phonology to morphology, syntax, and semantics. These students face challenges in getting the literal meaning or the general understanding of what they read, and they cannot remember facts and details that support the main ideas.

These studies reveal that many EFL students have major difficulties with reading comprehension even after years of learning English. Furthermore, previous research (Atkinson et al., 2017; Manarin et al., 2015; Sutherland & Incera, 2021) examined the cognitive difficulties that impact reading performance and concluded that lack of practice lead to hindering the ability to develop critical and analytical thinking skills. In addition, Wang et al. (2003) identified problems of struggling readers due to reading difficulty with the capacity of human memory, which affects saving and retrieving information. Such studies indicate that the challenges of acquiring reading fluency begin with letter and word recognition, sentence recognition, and meaning. For example, inability to recognize silent letters affects reading comprehension, as a result of inaccurate decoding of words and meanings (Amin, 2022). Eppard et al. (2020) assert that fluency is a significant skill which is correlated with comprehension, reading performance, and academic achievements. Furthermore, investigating solutions for students who struggle in reading, developing cognitive and metacognitive reading strategies is an effective factor that can foster reading comprehension among readers (Reza et al., 2013). Automaticity and repeated reading exercises can also help students to achieve fluency while interacting in predicting reading comprehension (Kieffer & Christodoulou, 2020; Swain et al., 2017). The cognitive skills that students need to improve their reading performance include attention, visual and auditory processing, sensory integration, and short-term and long-term memory (Hautala et al., 2022; Wang et al., 2003). According to Hautala et.al, students can develop their reading cognitive abilities when they monitor their cognitive processes. Previous studies (Bonifacci et al., 2022; Bone & Bouck, 2017; Chiang, 2019) also show that technology, and computer software can help students enhance reading comprehension and fluency. Such studies concluded that technology has helped students to develop their cognitive abilities, and consequently, develop their reading skills. For example, text-to-speech technology helps students to improve attention, memory, abstract thinking, critical thinking, and auditory and visual processing, and therefore students can improve loud and silent reading, reading speed, reading comprehension, and vocabulary building. In other words, technology works as an automatic scaffolding, helping students to improve their reading performance (Mirzaei et al., 2018, p. 202).

C. Implications of Assistive Technology

Assistive technology refers to any technology, including equipment or software, which can be used to improve the functional capabilities of learners who face difficulties in learning (Assistive Technology Industry Association- ATIA, 2004). Amin (2022) provided evidence on a number of issues related to the use of assistive technology in education, including improving learners' cognitive abilities; providing numerous opportunities for learning independence; and diversifying the learning materials. Text-To-Speech Software (TTS) is among the packages that assistive technology has provided to be used in the reading classroom. This read-aloud technology helps in facilitating the process of reading, motivating students to enjoy reading and interact with the text. TTS helps students to achieve their learning objectives by providing them with easier ways of comprehending the texts already put in loud words (Mirzaei et al., 2018). Using TTS, the reader's attention span is increased, and the interactivity with long-term memory is also increased, aiding learners to store most of the learned concepts to their memory, and improve their vocabulary performance (Chiang, 2019). According to Eksi and Yesilcinar (2016), TTS enhances learning since the access to the reading materials is facilitated, helping students to develop comprehension skills, attention to details, memory enhancement, and interactions to various types of readings, which influence the overall reading process. Therefore, EFL learners who use the TTS technology are bound to achieve progress in their cognitive abilities, and improve their reading performance.

D. Students' Cognitive Reading Abilities

Kmetz (2020), and Swanson and Siegel (2001) indicated that cognitive variables of reading, including reasoning skills, attention, short -term, and long-term memory, visual and auditory processing, and processing speed, impact students' reading performance. Cognitive variables also include interactions, decoding, comprehension, concept formation, visual matching, and re-expression of ideas, all of which affect students' abilities to not only read efficiently, but also use English in different communicative settings. Basaraba et al. (2013), and Garcia and Cain (2014) assert that when learners acquire advanced cognitive abilities, they become capable of not only understanding the texts they read, but also constructing literal and inferential meanings. Such studies conclude that there is a strong relationship between the ability to think critically, and reading performance. For example, critical thinking helps students to ask questions about the author's message, the meaning of implied and metaphorical language, the relevance of the content, and the purpose of reading itself. Thus, students' cognitive profiles help teachers to teach students how to read. Furthermore, enhancing cognitive abilities help students to accelerate reading speed, improve comprehension, and conduct phonological, structural, semantic, and rhetoric analysis, and holistic evaluation because critical thinking leads to critical reading. Mohseni et al. (2020) investigated the effects of cognitive and metacognitive strategies on improving EFL students' reading comprehension, asserting that such strategies as problem-solving, analytical thinking, and critical reading, help in raising students' awareness of the intrinsic aspects of reading comprehension. Previous research (Meniado, 2016; Villanueva, 2022; Zhao et al., 2022) also revealed a correlational relation between higher-order cognitive skills and reading performance.

III. METHOD

The current one group pretest-posttest quasi experimental study aimed to examine the relationship between TTS and cognitive reading abilities. The experimental design of cause and effect helped in examining the effect of assistive technology TTS on the Saudi female student's reading performance. The quasi-experiment included three phases: (1) the diagnostic phase through a questionnaire to identify EFL students' reading problems, and entry testing, to check students' reading performance; (2) training period using the integrated reading based-technology model Natural Reader software TTS; (3) posttest to check the final EFL students' reading performance after the training period of intervention, and a final questionnaire to check EFL learners' satisfaction of the TTS model.

A. Research Questions

1. What are the problems that EFL Saudi female undergraduate students face in reading?
2. What are the results of EFL students' test scores before and after using TTS Natural Reader Software?
3. What are the effects of assistive technology, specifically TTS, on EFL students' reading cognitive abilities?
4. To what extent are EFL students satisfied with Natural Reader software?

B. Participants

49 students participated in the study, selected from the Saudi female undergraduate students who study at the English Department at the College of Languages and Translation, at Imam Mohammed Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia. The age of the participants ranges between 18-20 years old. Their mother tongue is Arabic, and they have studied English for 6 years at school before they joined the university. The participants have not received any training on TTS technology, and they have not used Natural Reader software prior to this experiment. The participants did not study the reading text prior to test.

C. Instruments

The study utilized text to speech Natural Reader Edu by Natural Soft Ltd (2022) to measure the students' reading scores before and after the training period. Instruments also include two questionnaires: the first one was used to identify students' problems in reading; and the second one was used to examine their satisfaction with the software. The reading test aims to examine specific cognitive abilities, including the abilities to identify comprehension knowledge, vocabulary, visual-spatial thinking, critical and inferential thinking, auditory processing (e. g. loud reading), reading speed, and information retrieval.

D. Procedures

The pretest-posttest was prepared by the researcher based on Woodcock-Johnson III's cognitive variables (Woodcock et al., 2001), and which aims to examine cognitive abilities, and achievement. The comprehension text was selected from Douglas and Bohleke (2020). A worksheet was prepared by the researcher (see Appendix) to track reading progress. The training period targeted the application of Natural Reader TTS on a daily basis. In the final phase, the participants were given a questionnaire to know their degree of satisfactions with TTS software.

E. Research Limitations

The present study has several limitations. First, the experiment was limited to 49 female students, who study English at the College of Languages and Translation, at Imam University. These 49 students study reading, Level III, which is assigned in their second semester. In other words, the results of the study do not include students who study in different levels, or different courses of reading. The study also excludes all the male students who study the same course of reading, due to social constraints. Furthermore, the time span covered by the study was only one semester of the academic year 2023. Further investigation may include different levels of English for both male and female students.

IV. RESULTS

Data were analyzed using the statistical packages for Social Sciences (SPSS) version, (IBM-SPSS®, version 25.0), which helped in calculating the following: (a) frequencies and percentages to recognize the participants' responses about the research questions; (b) mean and standard deviation to identify the participants' responses; (c) paired sample t-test to determine the effects of assistive technology on the participants' cognitive abilities; and (d) ETA square to determine the effects of assistive technology on the participants' reading cognitive abilities. Descriptive (frequency, percentage, mean, and standard deviation) and inferential analysis (paired sample t-test) were used in the analysis.

Answering the Study Questions

Q1: What are the problems that EFL Saudi female undergraduate students face in reading?

Frequencies, and percentage of the individuals' responses were calculated to show the problems that Saudi female students face in their reading courses (n=48). The results showed that more than half of the respondents face reading problems (32), with percentage of (66.7%), while there were (3) students with percentage of (6.3%) who do not find it hard. 16 students with percentage of (33.3%) often like reading, while (2) students with percentage of (4.2%) never like it. Furthermore, (23) students with percentage of (47.9%) sometimes spend time to read every day, while (4) students

with percentage of (8.3%) always spend time to read every day. The results also find that (26) students, with percentage of (54.2%) read one book per week, while only (2) students with percentage of (4.2%) read more than three books per week. 18 students with percentage of (37.5%) sometimes like to read on their computers. The results also revealed that there were (15) students with percentage of (31.3%) sometimes prefer to listen to audiobooks rather than read books, while (6) students with percentage of (12.5%) between always and frequently prefer to listen to audiobooks. Moreover, the results also showed that, there were (15) students with percentage of (31.3%) can read less than 100 words per minute, while only (4) students with percentage of (8.3%) can read 200 words per minute. Additionally, about half of respondents (21) students with percentage of (43.8%) sometimes have problems with loud reading, while (3) students with percentage of (6.3%) always have problems with loud reading; besides the results find out there were (15) students with percentage of (31.3%) always prefer silent reading to loud reading, while (4) students with percentage of (8.3%) never prefer silent reading to loud reading. All of these results point to students' problems in reading fluency since students do not practice loud reading. The results also showed that there are many problems facing students when they read as (20) students with the percentage of (40.81%) have problems related to *pronunciation*, *vocabulary*, reading comprehension, *answering* indirect comprehension questions, and *summarizing* the reading text. These results indicate that students need to practice reading, using assistive technology to develop their reading speed, improve pronunciation, and increase vocabulary, all of which affect reading fluency.

Q2: What are the results of EFL students' test scores before and after using TTS Natural Reader Software?

As displayed in Table 1, the results showed that there were statistically significant differences at level of (0.01) between the mean scores of the EFL students in the pretest and posttest related to vocabulary building and its sub-dimensions (parts of speech suffixes, vocabulary antonyms) in favor of posttest with mean score of (7.38 ±1.09) for parts of speech suffixes, and (6.96 ±1.06) for vocabulary antonyms, and (14.33 ±1.40) for vocabulary building total score, ETA score amounted to (0.43, 0.72, 0.63) respectively. These results indicate that there was an effect of assistive technology on EFL students' reading cognitive abilities related to vocabulary building and its sub-dimensions, including parts of speech suffixes, and vocabulary antonyms (see Figure 1).
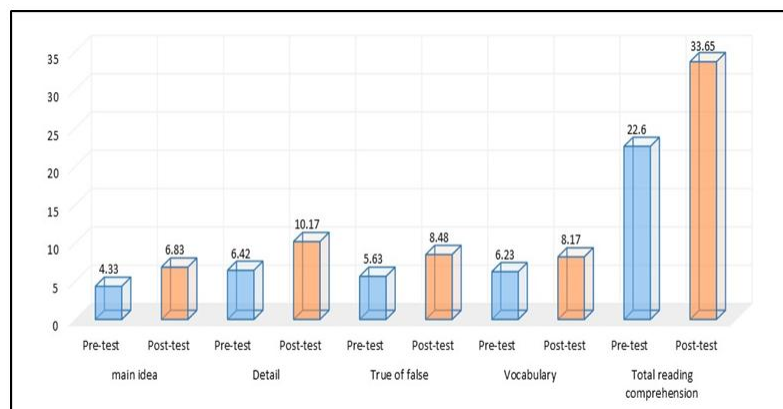

Figure1. Mean Scores of EFL Students in Pretest and Posttest in Reading Comprehension

As shown in Figure 1, the posttest revealed higher scores in the area of understanding the reading text main ideas, and the detailed information, identifying the true and false information, and understanding the meaning of the vocabulary as the total reading comprehension reached 33.65. Furthermore, the posttest results revealed higher scores in all areas of vocabulary with 14.33 compared to 6.48 in the pretest scores. In addition, the results also revealed that there were statistically significant differences at level of (0.01) between the mean scores of the EFL students in the pre and post related to the relationship between reading and writing an effective paragraph summary, showing a favor of post-test with mean score of (11.56 ±1.18) compare to (4.96 ±1.02) for pre-test, ETA score amounted to (0.57), these results indicate that there was an effects of assistive technology on EFL students' reading cognitive abilities related to reading and writing a paragraph summary (Table 1). The results showed that the posttest revealed higher score (11.56) compared to the scores of the pretest (4.96). In addition, the results showed that there were statistically significant differences at level of (0.01) between the mean scores of the EFL students in the pre and post related to critical thinking and its sub-dimensions (critical thinking QA), which involves reading with critical perspective, and (critical thinking QB), which involves solving problems in the reading text, in favor of post-test with mean score of (3.98 ±1.03) for critical thinking QA, and (4.23 ±1.04) for critical thinking QB, and (8.21 ±1.32) for critical thinking total score, ETA score amounted to (0.63, 0.59, 0.69) respectively, indicating that, there was an effect of assistive technology on EFL students' reading cognitive abilities related to critical thinking and its sub-dimensions (Table 1). Figure 2 displays these results.
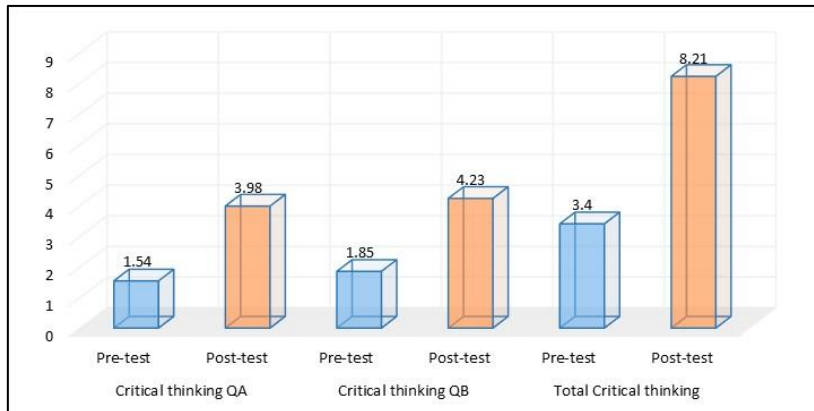
Figure 2. Mean Scores of EFL Students in the Pretest and Posttest Related to Critical Thinking

The results showed that there were statistically significant differences at level of (0.01) between the mean scores of EFL students in the pretest and posttest related to test total score in favor of post-test with mean score of (74.73 ±10.65) compare to (41.48 ±7.94) for pre-test, ETA score amounted to (0.75). These results indicate that there was an effect of assistive technology on EFL students' reading cognitive abilities (see Figure 3).
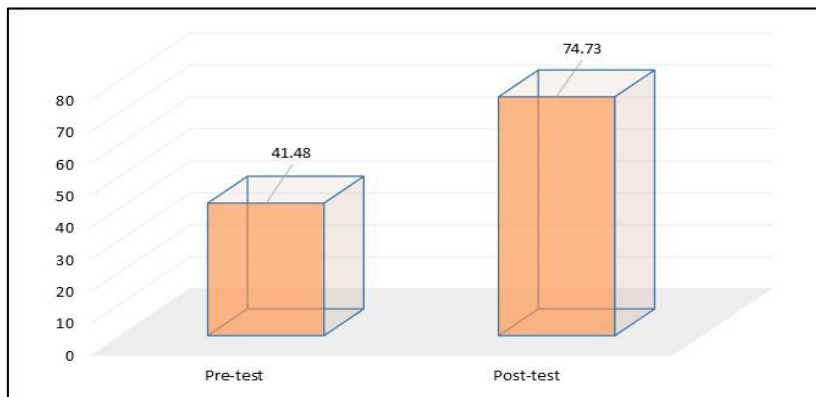

Figure 3. Mean Scores of EFL Students in the Pretest and Posttest Related to Total Score

Q3: What are the effects of assistive technology, specifically TTS, on EFL students' reading cognitive abilities?

To determine the effects of assistive technology on EFL students' reading cognitive abilities, paired sample t-test was calculated as follows:

TABLE 1
PAIRED SAMPLE T-TEST FOR EFFECTS OF ASSISTIVE TECHNOLOGY ON EFL STUDENTS' READING COGNITIVE ABILITIES (N=48)

Sections	Groups	N	Mean	SD	T	p. value	Eta Squared
Reading speed	Pre-test	48	4.04	1.04	7.513	0.001	0.61
	Post-test	48	6.98	1.08			
Main idea	Pre-test	48	4.33	1.03	3.509	0.001	0.34
	Post-test	48	6.83	1.08			
Detail	Pre-test	48	6.42	1.01	5.639	0.001	0.50
	Post-test	48	10.17	1.47			
True of false (Identifying information)	Pre-test	48	5.63	1.05	6.382	0.001	0.55
	Post-test	48	8.48	1.07			
Vocabulary	Pre-test	48	6.23	1.12	3.612	0.001	0.35
	Post-test	48	8.17	1.06			
Total reading comprehension	Pre-test	48	22.60	2.80	7.876	0.001	0.63
	Post-test	48	33.65	2.94			
Parts of speech suffixes/prefixes	Pre-test	48	3.42	1.00	4.641	0.001	0.43
	Post-test	48	7.38	1.09			
Vocabulary antonyms	Pre-test	48	3.06	1.01	9.966	0.001	0.72
	Post-test	48	6.96	1.06			
Total vocabulary building	Pre-test	48	6.48	1.22	7.934	0.001	0.63
	Post-test	48	14.33	1.40			
Paragraph summary	Pre-test	48	4.96	1.02	6.804	0.001	0.57
	Post-test	48	11.56	1.18			
Critical thinking QA (critical reading to write perspective summary)	Pre-test	48	1.54	0.66	7.935	0.001	0.63
	Post-test	48	3.98	1.03			
Critical thinking QB (critical reading to solve problems)	Pre-test	48	1.85	0.89	7.100	0.001	0.59
	Post-test	48	4.23	1.04			
Total Critical thinking	Pre-test	48	3.40	1.07	9.229	0.001	0.69
	Post-test	48	8.21	1.32			
Total scores	Pre-test	48	41.48	7.94	10.992	0.001	0.75
	Post-test	48	74.73	10.65			

Table 1 shows that there were statistically significant differences at level of (0.01) between the mean scores of EFL students in the pretest and posttests, related to reading speed in favor of posttest with mean score of (6.98 ±1.08) compared to (4.04 ± 1.04) for pretest, ETA score amounted to (0.61). These results indicate that there was an effect of assistive technology on EFL students' reading cognitive abilities related to reading speed (see Figure 4).
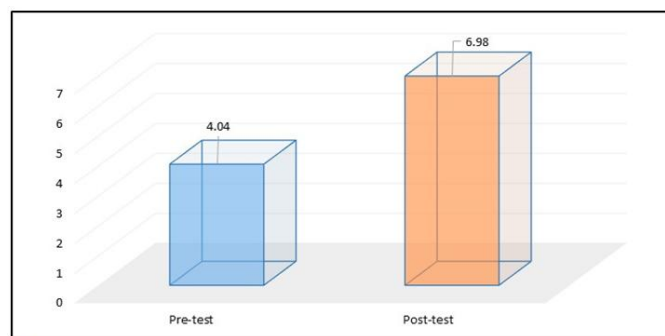

Figure 4. Mean Scores of EFL Students in Pretest and Posttest in Reading Speed

In addition, the results revealed that there were statistically significant differences at level of (0.01) between the mean scores of the students in the pretest and posttest related to reading comprehension and it's sub-dimensions (main idea , details, true / false information, vocabulary) in favor of post-test with mean score of (6.83 ±1.08) for main idea dimension, and (10.17 ±1.47) for detail dimension, and (8.48 ±1.07) for true or false dimension, and (8.17 ±1.06) for vocabulary dimension, and (33.65 ±2.94) for reading comprehension total score, ETA score amounted to (0.34, 0.50, 0.55, 0.35, 0.63) respectively. These results indicate that there was an effect of assistive technology on EFL students' reading cognitive abilities related to reading comprehension and its sub-dimensions (main idea, detail, true / false information, vocabulary). These results show that the overall reading performance of EFL students in the posttest is better than their performance in the pretest, indicating the positive impact of TTS on their reading performance.

Q4: To what extent are EFL students satisfied with Natural Reader software?

To determine the level of EFL student's satisfaction about Natural Reader software, the mean and standard deviation of the individuals' responses were calculated and the results showed that the level of EFL student's satisfaction about Natural Reader software was very high with a mean score of (4.21 ± 0.65), In this context, item number (1)" I am

pleased with Natural Reader Software" was the highly perceived item and ranked first with a mean score of (4.38± 0.70) which refers to "strongly agree" with the percentage of (87.5%), followed by item number (4) (Natural Reader Software helped me to improve my vocabulary), with a mean score of (4.33± 0.69) which refers to "strongly agree" with the percentage of (86.7%), and in the third place comes item number (3) (Natural Reader Software helped me to improve my pronunciation) with a mean score of (4.33± 0.96) which refers to "strongly agree" with the percentage of (86.7%). Item number (11) (Natural Reader Software helped me to improve my focus on the main message of the text when I read) is listed in the fourth place with a mean score of (4.29± 0.90) which refers to "strongly agree" with the percentage of (85.8%), and in the four tenth place comes item number (6) (Natural Reader Software helped me to improve my inferential understanding) with a mean score of (4.06± 0.81), which refers to "agree" with percentage of (81.3%), then item number (7) "I Natural Reader Software helped me to improve my critical thinking", is ranked last with a mean score of (4.0 ± 0.95), which refers to "agree" with the percentage of (80.0%). Thus, the results show the effects of assistive technology, specifically TTS, on EFL students' reading cognitive abilities.

V. DISCUSSION AND FINDINGS

The findings are in harmony with previous research. For example, Al-Qahtani (2016) revealed that Saudi students experience the same reading issues, including knowledge of limited vocabulary, difficulty in grasping the meaning of the text, and errors in word recognition, and pronunciation problems (pp. 4-11). Similarly, Durukan (2020), and Buzick and Stone (2014) found problems related to reading speed and its negative impact on comprehension skills as the study showed that reading too fast or too slowly resulted in weakness in concentration and comprehension. Furthermore, previous results found that the majority of students have problems with reading material and cannot read with the needed insight, and that these students experienced problems with understanding what they read, and specifically, they struggle to understand difficult words (Andrianatos, 2019, p. 4). In this respect, Martins and Capellini (2021) assert that problems with loud reading, reading speed, reading comprehension, and limited vocabulary affect negatively reading fluency, and consequently reading proficiency. Furthermore, the results which revealed the positive effect of assistive technology on students' reading cognitive abilities, are compatible with previous research findings. For example, the finding of Amin (2022), Chiang (2019), and Eksi and Yesilcinar (2016) affirmed that assistive technology improved learners' cognitive abilities by providing them with many opportunities for becoming independent readers, capable of reading, thinking, understanding, analyzing, and expressing their perspectives on what they read. The results also revealed the positive impact of assistive technology on developing cognitive abilities, and reading performance. In a different study by Mardiana and Kaisar (2019), the results showed the significant impact of technological determinism on new literacies in the learning process, including reading. Graesser (2016) affirms that technology can work as auto tutor to motivate students to read. Similarly, Hautala et al. (2022) assert that assistive technology helps students to acquire cognitive skills, which are required to improve their reading performance since technology assists them to improve attention, visual and auditory processing, and short-term and long-term memory. In similar findings, Cauley et al. (2019) assert that TTS technology helps students improve vocabulary, reading comprehension, and reading fluency. Regarding the level of student's satisfaction about Natural Reader software, it was very high, with the mean score of (4.21 ± 0.65). Reflecting on these results shows that the features of automaticity play an important role in training students to improve their cognitive reading abilities. In this light, Kieffer and Christodoulou (2020), and Swain et al. (2017) concluded that the features of automaticity and repeated reading exercises help students to achieve fluency while interacting with reading comprehension. Because TTS technology is highly integrative, it can facilitate the reading process. In this regard, Silvestri et al. (2022) indicate that TTS assist learners to improve their cognitive competencies that are involved in reading comprehension, including critical analysis, lexicon, phonological, and syntactical understanding, which lead to developing reading fluency. Hence, the findings of the current study provide empirical evidence on how technology functions as an automatic scaffolding, assisting EFL students to improve their reading performance. Another implication is that these findings pave the way for developing the reading courses at the College of Languages and Translation, at Imam University, integrating assistive technology, specifically TTS to help students become better readers. Moreover, the integration of the theory of process information into TTS helps in designing a new reading model that encompasses the reading cognitive profile, allowing EFL students to develop their attention, and critical and analytical thinking while improving reading speed and reading fluency.

Thus, the findings show that integrative proposed model (see Figure 5) that was applied in the current study allows EFL students to use visual information, which includes phonological and episodic memory to understand the semantic components of the reading text. The effectiveness of information processing theory is that it does not only show how information is grasped, but it also helps learners to store and retrieve what they read (Kmetz, 2020; Wang et al., 2003). Since the TTS software also targets memory enhancement, it is compatible to be integrated into models of information processing (Atkinson & Shiffrin, 1977; Baddeley & Hitch, 2019). Based on these results, future applications of this integrative model (see Figure 5) can be conducted.
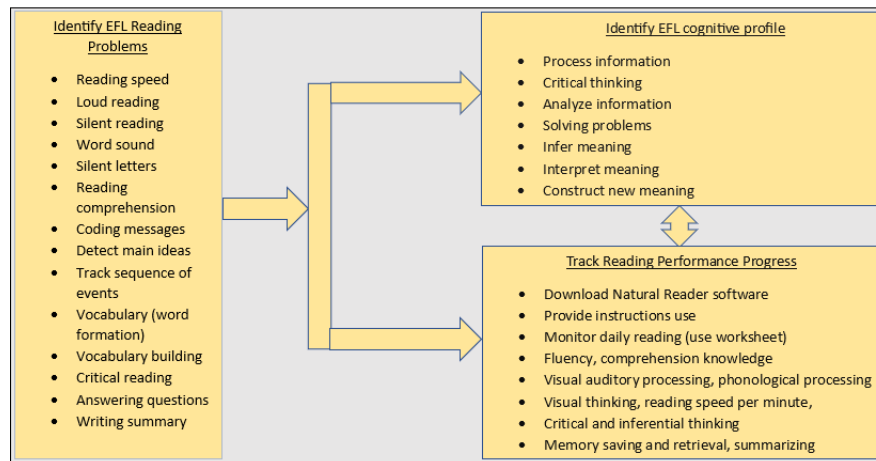
Figure 5. Proposed Integrative Based-Technology Reading Model (by the Researcher)

As displayed in Figure 5, the procedures of using this model begin by identifying the EFL students' reading problems in 14 categories which include reading speed, loud reading, silent reading, word sound, silent letters, reading comprehension, coding messages, detect main ideas, track sequence of events, vocabulary (word formation), vocabulary building, critical reading, answering questions, and writing summary. The second procedure is to identify the EFL student's cognitive profile, which include process of information, critical thinking, analyzing information, solving problems, inferring the meaning, interpreting the meaning, and constructing new meaning. The last procedure involves tracking students' reading performance progress, while using the software (see Appendix). This model served the purpose of the study, which aimed at using TTS for scaffolding EFL students to improve their reading comprehension, perception and processing of information, and interactions to comprehension questions.

VI. RECOMMENDATIONS AND CONCLUSION

The current study investigated the reading difficulties that EFL Saudi female undergraduate students face, and found that there is a necessary need for interventions to help them develop their cognitive reading abilities in order to improve their reading performance. Guided by Woodcock et al. (2001) cognitive categories of reading comprehension and achievements, the researcher developed a new reading model that integrates Text-To-Speech (TTS) software Natural Reader, and information processing theory, that was used in the intervention phase. The purpose of using this integrative reading model is to help EFL students modify their reading habits, attitude, and behavior, and motivate them to intrinsically adopt new cognitive reading strategies. Thus, TTS technology is used as a scaffolding tool to enhance learners' cognitive abilities. Although Natural Reader software has been used by a number of universities in USA and Canada for quite some time, yet, it has not been used at Imam University, Saudi Arabia. The features of Natural Reader software include, practices of loud reading, reading speed, phonological recognition, perception of the relationship between visual and auditory protocols of reading, information processing, vocabulary building, and memory enhancement. The present study provides evidence that such features help students improve reading fluency, understand the reading text word by word, and sentence by sentence, which can help in improving holistic comprehension. Using this software, students can better identify difficult words and recognize their meanings, improve reading speed, improve pronunciation, develop cognitive abilities to store and retrieve information, and answer comprehension questions. Previous research findings support the use of assistive technology in the reading classroom, specifically, TTS, as it provides a solution for the students who face difficulties in reading. The findings of the present study are in harmony with previous findings, indicating that the overall reading performance of students in the posttest is better than their performance in the pretest, affirming the positive impact of TTS on reading performance. Furthermore, the follow up worksheet that is integrated in this reading model also helps students to trace their progress on a daily basis, and which leads to achieving reading fluency. The study also provides a better understanding of how TTS can be used as a comprehensive training program to improve EFL students' reading performance. Finally, the study provides some recommendations for further investigations of the linguistic changes that EFL students experience due to the use of assistive technology in learning the English skills. The integrative reading model proposed and used in the present study can be used as a new avenue for many EFL students to achieve their academic objectives. Thus, the contribution of this study stems from the empirical evidence, which the research findings provide, regarding the effectiveness of integrating reading information processing theory into TTS technology. The success of the training phase of the study provides a practical example of the integration of technology in EFL, contributing to both the fields of applied linguistics and educational technology since the study provides more insights about the role that assistive technology plays in shaping the language classroom, whether it is conducted online, or a mixture of traditional learning and blended settings.

APPENDIX

* EFL Student's Daily Progress Worksheet Using TTS Integrative Reading Model

Week/Day	Reading Speed Count number of words being read per minute	Vocabulary New vocabulary learned Vocabulary building (parts of speech)	Phonological processing (pronunciation, sound recognition) of words you learned	Verbal Comprehension (Comprehension knowledge, lexical knowledge) Identify new Knowledge	Sound Blending (auditory processing, phonetic coding)	Reading Comprehension (identifying new ideas and new details, sequence of events)	Critical Thinking (Understanding opposing ideas, grasping implied /inferential meaning	Memory (a) visual-auditory (long-term retrieval) (names, words, and information (b) spatial relations (visual-spatial thinking, visualization of spatial relations	Summarize and interpret (understanding opposing ideas, grasping implied meaning) Write 3 ideas from the text you read
Day 1-7 (Report daily progress in each column) ⇨									

*This worksheet is based on Woodcock-Johnson III's cognitive abilities (Woodcock, McGrew, & Mather, 2001), which focus on the following categories: (a) verbal comprehension (comprehension-knowledge, lexical knowledge); (b) visual-auditory (long-term retrieval); (c) spatial relations (visual-spatial thinking, visualization of spatial relations); (d) sound blending (auditory processing, phonetic coding); (e) reading speed (count words per minute); (f) reading comprehension (identifying new ideas and new details); (g) phonological processing (pronunciation, sound recognition); (h) critical and inferential thinking (understanding opposing ideas, grasping implied meaning); (i) memory for names, words, and information; (j) summarize and interpret (express opinions, interaction with the meaning.

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