www.ijemst.net

The Impact of a Cognitive Neuroscience-Based Educational Program on Developing Reading Comprehension Skills among Intermediate Stage Students

Hala Alhag Alameen Sulieman
Department of Curriculum and Teaching Methods, College of Education, Najran University, Saudi Arabia

Ibrahem Mohammed Abdullah Alamoush
Sharjah Education Academy, Sharjah, United Arab Emirates

Kholoud Abdulraheem Auwid Al Shdaifat
Department of Arabic Curriculum and Teaching Methods, College of Education, Najran University, Saudi Arabia

To cite this article:

Sulieman, H.A.A., Alamoush, I.M.A., & Al Shdaifat, K.A.A. (2024). The impact of a cognitive neuroscience-based educational program on developing reading comprehension skills among intermediate stage students. *International Journal of Education in Mathematics, Science, and Technology (IJEMST), 12*(3), 575-589. Https://Doi.Org/10.46328/Ijemst.4051

International Journal of Education in Mathematics, Science and Technology

2024, Vol. 12, No. 3, 575-589 https://doi.org/10.46328/ijemst.4051

The Impact of a Cognitive Neuroscience-Based Educational Program on Developing Reading Comprehension Skills among Intermediate Stage Students

Hala Alhag Alameen Sulieman, Ibrahem Mohammed Abdullah Alamoush, Kholoud Abdulraheem Auwid Al Shdaifat

Article Info

Article History

Received:
12 May 2023
Accepted:
25 November 2023

Keywords

Educational program
Cognitive neuroscience
Reading comprehension skills
Second-grade intermediate school students

Abstract

The current study investigates the impact of an educational program based on cognitive neuroscience on developing reading comprehension skills among second-grade students in the Kingdom of Saudi Arabia. To achieve this objective, the researchers employed a quasi-experimental design, selecting a sample of 59 students from Princess Nora bint Abdulrahman Al Saud School for Girls and Al-Madinah Al-Jamia Educational School for Boys, both under the supervision of the Education Directorate in Najran region. The sample was divided into two groups: 30 students in the experimental group and 29 in the control group. The researchers developed two instruments: a cognitive neuroscience-based educational program and a written test. After ensuring their validity and reliability, these instruments were administered to the study participants. The results revealed statistically significant differences in favor of the experimental group, while no significant differences were found based on gender or the interaction between gender and group. In light of the results, the researchers provided a set of recommendations.

Introduction

Language is a crucial factor in human communication and scientific advancement. It serves as the key to growth, learning, and thinking. In educational settings, learning reading comprehension appears to be a straightforward process involving students gathering in classrooms with their teachers to learn letters, vocabulary, texts, and language rules. While this is true to some extent, there are unseen interactions, specifically the changes that occur in students' brain structures. The brain, the center of cognitive processes, remains in a state of continuous growth throughout an individual's life. Tau and Peterson (2010) note that the brain continues to grow as long as the person is alive. However, this growth and development rely on continuous learning processes, with a significant impact stemming from engaging in reading comprehension activities. During learning reading comprehension, the brain interacts deeply with these cognitive processes. Mastering these processes and skills leads to changes in the brain structure at the linguistic abilities level and the size of the brain mass, with an increase in the size of some brain areas associated with language. The improvement and increase in brain size reflect in the growth of reading

comprehension skills. Learning to read and master it involves a complex process that stimulates the brain to build a neural network connecting nerve cells through a process called synapses. According to Zhang (2019), each nerve cell can connect with up to 10,000 neural synapses with other nerve cells. This brain feature is known as neuroplasticity, describing the brain's remarkable ability to change its structure or reshape it in response to environmental stimuli, cognitive demands, or behavioral experiences (Li et al., 2014). However, the most impactful aspect of neuroplasticity is the use of reading processes as they bring about significant changes in the brain and activate communication between nerve cells. Despite the importance of reading comprehension skills and their impact on future academic and professional success, students still face challenges while acquiring these skills. Teachers also face difficulties, especially after experiencing educational losses due to the COVID-19 pandemic, which has resulted in reported deficiencies in language skills and reading comprehension skills.

Given the current reality, the present study aims to align with ongoing calls to highlight reading comprehension skills, given their pivotal role in achieving diverse educational learning outcomes. The importance of the current study can be summarized in the significance of reading comprehension skills and their pivotal role in students' academic and life success. Additionally, there is a call from teachers and educators to provide teaching methods and educational programs that enhance the development of reading comprehension skills among students. The study also underscores its significance by highlighting that researchers have not found any previous study addressing the development of reading comprehension skills through an educational program based on cognitive neuroscience in the Arabic language for intermediate school students in the Kingdom of Saudi Arabia. Many researchers (Al-Attar & Al-Tamimi, 2023; Morrison & Wilcox, 2020; Javourey et al., 2022) have affirmed that students suffer from a noticeable weakness in reading comprehension skills. This places an additional burden on teachers and educators, prompting calls for developing effective methods and strategies to enhance these skills.

Based on the researchers' observations and their close work with students in schools, as well as their direct supervision and training of teachers on strategies for developing reading comprehension skills, they note that the reading comprehension skills of intermediate school students fall short of expectations. To precisely define the research topic, the researchers attempted to answer the following research questions:

1. Is there a statistically significant difference at the significance level ($\alpha \geq 0.05$) between the control group and the experimental group in reading comprehension attributed to the training program?
2. Is there a statistically significant difference at the significance level ($\alpha \geq 0.05$) in reading comprehension among second-grade intermediate school students in the Kingdom of Saudi Arabia (males, females) attributed to gender (males, females)?
3. Is there a statistically significant difference at the significance level ($\alpha \geq 0.05$) in reading comprehension among second-grade intermediate school students in the Kingdom of Saudi Arabia (males, females) attributed to the interaction between the program and gender (males, females)?

Theoretical Framework

Understanding a written text remains a paramount objective pursued by those involved in the educational process through instructional procedures that address reading texts. Despite significant advancements and the accelerating

pace of technology and communication tools, the importance of reading comprehension persists within this evolution. This progress primarily relies on reading, the kind of reading that goes beyond decoding written symbols to reach higher levels of comprehension, such as critical analysis and creativity.

Al-Rashidi and Haji (2021) perceived reading comprehension as a complex process involving multiple levels that take place in the reader's mind, focusing on extracting the hidden meanings in the read texts for understanding, interpretation, inference of their significance, criticism, appreciation, and application in various fields by linking prior experiences with new ones. Silalahi et al. (2022) defined reading comprehension as the brain's ability to comprehend meaning in significant matters, and to understand and explore social phenomena in the written text. Al-Saidawi (2015) viewed reading comprehension as the foundation of the reading process, reserving a place for it. Reading holds no value without understanding, as comprehension is the goal of reading, representing the pinnacle of reading skills for mastering language skills as a whole. Given the importance of reading comprehension, researchers have sought to categorize it into levels, with some levels building upon others. One such categorization, as proposed by Atif (2018), consists of four levels: Direct comprehension level involving the identification of word meanings, synonyms, and antonyms, as well as extracting the main idea and secondary ideas; inferential comprehension level encompassing the inference of implicit ideas, identifying values expressed in the text, and deducing relationships between causes and effects; critical comprehension level signifying the ability to differentiate between opinions and facts, and issuing judgments on the material, whether it be personal an event, or a situation; and creative comprehension level regarded as the pinnacle of comprehension levels, involving the reconstruction of the material and suggesting a greater variety of suitable titles, among other aspects.

Additionally, Ahmed (2011) and Hashim et al. (2016) suggested that reading comprehension manifests in five levels: Direct comprehension, inferential comprehension, critical comprehension, aesthetic comprehension, and creative comprehension. Looking at the diversity of reading comprehension levels presented by researchers, it is evident that they revolve around the same sphere. Therefore, the researchers have seen that these levels can be considered as four: Literal level, inferential level, critical level, and creative level. Each of these levels encompasses a set of skills. Fung et al. (2003) emphasized that to achieve the highest levels of understanding of the material being read, it is essential to engage in comprehension processes at all levels during the reading process. This includes cognitive and metacognitive thinking processes. Improving these processes enhances the level of comprehension, adding an element of enjoyment to the learning of reading. This is achieved for students when they can employ reading comprehension strategies flexibly and easily during the reading process.

Teaching higher-level reading comprehension, according to Hoffman et al. (2020), requires instructing students differently, and using organized strategies and programs so that students acquire the necessary skills. This enables them to view various issues in the text with a broader and more open perspective. Al-Amoush and Al-Jahni (2016) argued that understanding is the tool students use to learn how to navigate texts, engage in dialogue with them, generate questions for extracting results, think critically during reading, problem-solve, identify gaps, predict, imagine, and generate multiple possible scenarios. This involves employing different thinking skills to construct new meanings from the text, and this type of reading falls within the higher levels, with creativity being the highest level.

In modern language education, cognitive neuroscience has emerged as a contemporary concept. Recent research in studying the structure and functioning of the brain, utilizing advancements in technology and cognitive neuroscience studies, has led to the development of new educational frameworks that explain the nature of the reading process and its occurrence in the brain. Duman (2010) suggested that a lack of understanding of the brain's functioning system would hinder our ability to comprehend the nature of learning. Learning based on brain processes provides a better approach to learning and caters to individual differences effectively. Lotfallah (2012) emphasizes that adopting neuroscience-based learning requires three essential elements: The teacher responsible for creating interactive learning experiences that align with the brain's processes; the learner learning should be characterized by challenge and personal motivation for active learning; and the active processing supporting the provision of effective opportunities to build new experiences.

The theories based on neuroscience, specifically neurolinguistics, suggest that language learning shapes the brain through neural connections. Neuroscientists have identified areas of the brain responsible for language and its functions. Alawi (2016) mentioned that different brain regions regulate the process of language learning and its complex uses, distributed across a range of memories that assist in recalling words, people, and situations, and the ability to use them linguistically. The brain, with its initial structure, is designed for general learning and language acquisition in particular. It is not a blank slate but a network of constantly communicating cells that organize thinking and language use based on the level of linguistic stimuli. Müller et al. (2023) illustrated that when a reader engages in language activities such as reading, writing, listening, or speaking, distinct areas of the brain are notably activated. This activity has been demonstrated through Magnetic Resonance Imaging (MRI) and functional Magnetic Resonance Imaging (fMRI). Reading processes and comprehension require the interaction between different regions of the brain. For this interaction to occur, communication is essential among the nerve cells connecting these regions, and this communication happens through two types: electrical communication and hormonal communication. Gazzaniga (2008) notes that the brain's ability to communicate between its regions varies from person to person, depending on the neural pathways built by the learner between these different areas. Building and reinforcing these neural pathways are significantly enhanced through the conscious practice of reading skills. By constructing and strengthening these pathways, specialized regions for reading are established.

Many students face various challenges in different stages of education due to low reading proficiency and weak reading comprehension. To assist students in overcoming these challenges, it is crucial to understand how the brain works during reading comprehension and develop educational strategies based on the understanding of the brain's neural system. Neuro-linguistics focuses on the relationship between word recognition, sub-processes of reading comprehension, and the interaction of cognitive processes, memory, and emotions to enhance reading comprehension. Kweldju (2015) raised the question of why researchers emphasize that reading engages multiple parts of the brain. The answer lies in the fact that reading and comprehension processes require a diverse set of skills, such as decoding, monitoring, questioning, predicting, retrieval, logical reasoning, and evaluation. Activating these skills involves more than one area of the brain, distributed across different brain regions rather than concentrated in a single location. Examples include short-term and long-term memory and working memory, among others. Cognitive skills alone do not operate during the process of understanding the text; there is an active network known as the emotional network. Hamedi and Fadardi (2020) clarified that emotions play a crucial role

in supporting the processes of understanding the text by building interconnected associations between neural cells. It is essential to consider the atmosphere and feelings accompanying reading as highly significant, recognizing them as a crucial factor in text comprehension. Positive emotions accompanying reading enhance text comprehension, while negative emotions and atmospheres hinder the process of understanding the text.

Taking a closer look at what happens in the brain during the reading process, the limbic system and paralimbic regions, according to Silvira and Suyadi (2023), evoke interactions and connections with the hypothalamus and brainstem nuclei to establish relationships and connections between the perception of the meaning of the text and its understanding on one hand and emotions on the other hand, storing them in memory. This confirms that linguistic aspects are processed on the left side of the brain, while emotions related to the text are processed on the right side of the brain. Swart and Jong (2023) explained that hormones such as dopamine, which increase concentration and attention levels, accompany the process of understanding the text, facilitating linguistic processing in the brain. This aligns with the perspective of Ellis and Bloch (2021) that emotions play a primary role in basic cognitive performance, forming the foundation of all brain functions. Based on the findings of neuroscience research, it is crucial to approach reading processes with a holistic perspective, considering cognitive, linguistic, and emotional components. When targeting reading comprehension, one essential factor to consider is the cognitive load of working memory. Perkins and Jiang (2019) indicated that as the reader processes an increasing amount of information, cognitive load increases leading to difficulties in understanding. Therefore, readers should not exceed their cognitive capacity to ensure comprehension. A concept that significantly contributes to enhancing reading processes is the working memory capacity. Jensen (2005) mentioned that working memory can accommodate 5-7 pieces of information at once, and the time it takes for information to transition from working memory depends on the student's cognitive abilities and familiarity with the information. Recognizing the limited capacity of working memory has led to the concept of Bite-Sized Learning, emphasizing that direct instruction should not exceed (5) minutes. Mark Barnes, in "The 5-Minute Teacher," supported this concept, suggesting that after direct instruction, students should apply what they have learned independently or collaboratively, followed by a return to direct instruction. Therefore, teachers should enhance their students' focus by segmenting class sessions and providing opportunities for students to explore reading topics independently and collaboratively. Bite-Sized Learning aims to increase the efficiency and capacity of working memory through its segmented approach.

Elsa and Bloch (2021) shed light on how the brain operates during reading, emphasizing comprehension as an active predictive process reliant on context. The brain actively senses prediction errors during reading, allowing it to build understanding and predict words before reading them. This is achieved through the interplay of systems involved in the reading process. Their perspective forms a clear understanding of the reading comprehension process, which is bidirectional, passing through hierarchical systems and influenced by emotions, shifting from the limbic system to the neocortex. This concept aligns with the work of Goodman et al. (2016), who clarified that reading involves two neural pathways: a direct pathway and an indirect pathway. The direct pathway is a powerful biological mechanism that enables beginner readers to learn without the explicit need for decoding. Consequently, the brain perceives the whole and then perceives the parts usually later, in a contextual process. In the case of gaps in understanding, the brain fills them using the reader's prior experiences. As for the indirect

pathway, it involves processing information in a complex and indirect manner before the reader comprehends it. This process entails a series of significant interactions that the information and data undergo to make reading a detailed and analytical process. This pathway includes the prefrontal cortex responsible for initial analysis and decision-making regarding the importance of the read information. It then moves to the parietal cortex, which engages in deeper processing to understand the read information. The cingulate cortex processes emotional data in the read information, determining the quality and quantity of emotional responses. The medial cingulate cortex analyzes the read information, sets priorities, and classifies them. This perspective highlights that the reading process is distributed across different regions of the brain. Based on this awareness of the cognitive neural nature of the reading process and the understanding of changes occurring in the brain structure as a result of learning reading skills, the presentation of reading processes must align with the neural nature of the brain. Teaching methods and approaches should be designed to be more effective in students' learning and enhance their cognitive abilities by activating the brain regions responsible for understanding the written text.

Researchers have addressed the topic of reading comprehension skills. Al-Shawawreh and Al-Matari (2020) conducted a study aiming to identify the impact of the electronic mind mapping strategy on developing reading comprehension skills and attitudes towards reading among ninth-grade female students. The study used a quasi-experimental design with a sample of 61 students. The results showed statistically significant differences in reading comprehension skills in favor of the experimental group, recommending the adoption of this strategy in teaching Arabic language curricula. Youssef (2021) conducted a study to investigate the effect of training on the International Student Assessment (PISA) test models in improving the reading comprehension performance of tenth-grade students. The study, using a quasi-experimental design with a sample of 54 students, revealed statistically significant differences in reading skills in favor of the experimental group. Khatatbeh et al. (2020) aimed to understand the impact of the dialogue circle and mental visualization strategies on students' performance of eighth grade in reading comprehension. The quasi-experimental study, with a sample of 76 students, showed statistically significant differences in reading comprehension skills in favor of the experimental group.

Al-Ghamdi (2020) conducted a study to investigate the effectiveness of the mental visualization strategy in developing reading comprehension and attitudes toward reading among sixth-grade female students. The quasi-experimental study, with a sample of 37 students, demonstrated statistically significant differences in reading comprehension skills in favor of the experimental group. Al-Abdulaziz and Al-Naanaa (2021) aimed to understand the impact of a strategy based on beyond-comprehension skills in developing reading comprehension among eighth-grade students in Jordan. The quasi-experimental study, with a sample of 60 students, revealed statistically significant differences in reading comprehension performance in favor of the experimental group. Al-Hawamdeh (2021) conducted a study to examine the effectiveness of the Kitsu strategy in developing reading comprehension skills among seventh-grade students in Jordan. The quasi-experimental study, with a sample of 50 students, showed statistically significant differences in the level of reading comprehension performance in favor of the experimental group. Rizk and Al-Otoum (2018) sought to understand the impact of a mental imagery-based educational program on developing reading comprehension among seventh-grade students in Jordan. The quasi-experimental study, with a sample of 80 students, indicated statistically significant differences favoring the experimental group in reading comprehension performance. Considering the findings of these studies and the

existing literature, it underscores the importance of reading comprehension skills and the subsequent impact on students' learning in various educational stages. The struggles students face in acquiring these skills are attributed to various reasons, including the mismatch between teaching methods and how the brain learns.

Methods

Population and Sample of the Study

The study population consisted of second-grade intermediate students from two public schools in Najran region during the academic year 2022-2023. The selected schools were Al-Madina Al-Jamea Educational Complex and Princess Bint Abdulrahman Al Saud School. The sample was chosen randomly and comprised 59 students, including 31 male students and 28 female students. Prior approvals for the study were obtained from Najran University, as well as the administrations of the mentioned schools and students' parents.

Study Tools

Researchers designed research tools by scientific procedures, and below is a detailed description of each tool:

A. Educational program: It aims to develop cognitive and mental abilities among second-grade intermediate students in the Najran region, improving their reading comprehension skills at different levels (literal, inferential, critical, and creative). The researchers studied reading comprehension skills and selected the most relevant ones for the current study, summarized as follows: The literal level that includes identifying the main idea in the text, identifying the central theme of the reading, recognizing supporting details for the main idea, identifying the relationship between the main idea and supporting details, differentiating between the main idea and supporting details, and explaining how supporting details reinforce the main idea. The inferential level includes inferring something beyond the text, determining causes and effects from the reading, explaining factors influencing the reader's judgment of the author's intention, utilizing details from the reading to infer the author's intention, and distinguishing between literal and figurative language. The critical level includes expressing the reader's opinion using personal words, evaluating the quality of the reading material, forming an opinion about a specific point in the reading, and making judgments about characters mentioned in the reading. The creative level includes presenting new ideas not covered by the author, providing new solutions to a problem or situation not mentioned in the reading, changing the ending of the reading, proposing a different title for the reading, and transforming the reading from one literary form to another (poem, essay, story, etc.). To support reading comprehension skills, the program included various interactive activities such as reading tasks, group work, discussions, interpretation, inference, comparison, criticism, and creativity. The program covers ten lessons from the "Lughati Al-Khalidah" textbook for second-grade intermediate students, addressing the program's objectives and skills. Regarding the validity of the educational program, it was initially presented in its draft version to a group of experts in Arabic and English language and education. Their opinions were considered regarding the program's skills, educational procedures, and suitability for the study sample. Their feedback was taken into account for refining the program and adjusting some of its steps.

B. Reading Comprehension Test: It is a primary tool in this study, designed to measure the development of reading comprehension skills among second-grade intermediate students. The test was constructed using a text outside the reading book, titled "Between Creativity and Diligence." This text had not been previously studied by the students. The test comprised eleven essay-type questions, except one multiple-choice question. The test duration was two class periods. The researchers initially presented the test in its draft form to evaluators specializing in Arabic and English language for authenticity. This aimed to assess the validity of the test questions in terms of technical and linguistic aspects and the extent to which the test questions measure reading comprehension skills. The evaluators provided suggestions and comments, which the researchers considered when modifying or replacing certain questions. To ensure the reliability of the Reading Comprehension Test, the researchers conducted a test-retest reliability analysis. The test was reapplied after two weeks to a pilot sample of 30 students who were not part of the main study. Pearson correlation coefficients were calculated between the scores of the two administrations. The internal consistency reliability was also calculated using the Cronbach's alpha equation. Table 1 illustrates the internal consistency reliability coefficient (Cronbach's alpha) and the test-retest reliability for the reading comprehension test. The obtained values were considered suitable for this study.

Table 1. Internal Consistency Reliability (Cronbach's Alpha) and Test-retest Reliability for the Reading Comprehension Test

	Reading Comprehension Test	Internal Consistency Reliability
Reading Comprehension Test	0.91	0.85

The pre-and post-reading comprehension tests were corrected by two raters: one researcher involved in the current study and another Arabic language teacher who received training from one of the researchers. The inter-rater reliability was calculated to assess the agreement between the two raters and subjected to statistical analysis. To ensure the equivalence of the control and experimental groups, the researchers computed the means and standard deviations for the scores of the study sample on the reading comprehension test based on group and gender variables. Table 2 illustrates these descriptive statistics.

Table 2. Means and Standard Deviations of the Scores for Second-grade Intermediate School Students in the Kingdom of Saudi Arabia on the Reading Comprehension Test According to Group and Gender Variables

Group	Gender	Mean (M)	Standard deviation (SD)	No.
Experimental	Male	4.29	1.603	18
	Female	5.42	2.646	12
	Total	4.74	2.116	30
Control	Male	4.98	1.235	13
	Female	5.08	1.227	16
	Total	5.03	1.210	29
Total	Male	4.58	1.478	31
	Female	5.22	1.929	28
	Total	4.89	1.722	59

Table 2 shows apparent variations in the means and standard deviations of the scores for the study sample on the reading comprehension test due to the differences in the categories of the group and gender variables. To demonstrate the statistical significance of the mean differences, a two-way analysis of variance (ANOVA) was employed, as indicated in Table 3.

Table 3. The Two-way Analysis of Variance (ANOVA) for the Effect of Group and Gender on Second-grade Intermediate School Students' Scores in the Kingdom of Saudi Arabia on the Reading Comprehension Test

Source of variance	Sum of squares	df	means of squares	F	Sig.
Group	.442	1	.442	.150	.700
Gender	5.369	1	5.369	1.827	.182
Group * gender	3.794	1	3.794	1.291	.261
Error	161.595	55	2.938		
Total	172.040	58			

Table 3 reveals the absence of statistically significant differences ($\alpha \geq 0.05$) attributed to the effect of the group, the effect of gender, or the interaction effect between the group and gender. This result indicates the equality of the groups.

Results

To answer the research questions, the means, standard deviations, and adjusted means were calculated for the grades of second-year intermediate school students in the Kingdom of Saudi Arabia in the pre-test and post-test of reading comprehension skills according to the variables of group and gender, as shown in Table 4.

Table 4. Means, Standard Deviations, and Adjusted Means for the Grades of Second-Year Intermediate School Students in The Kingdom of Saudi Arabia on The Overall Reading Comprehension Skills Test for both Pre-test and Post-test, According to the Variables of Group and Gender

Group	Gender	Pre-test			Post-test		Adjusted mean	Error
		No.	Mean	Standard deviation	Mean	Standard deviation		
Experimental	Male	10.26	4.29	1.603	2.769	18	10.575	.645
	Female	11.29	5.42	2.646	3.011	12	11.013	.783
	Total	10.68	4.74	2.116	2.863	30	10.794	.500
Control	Male	6.65	4.98	1.235	1.908	13	6.604	.745
	Female	8.86	5.08	1.227	3.261	16	8.758	.672
	Total	7.87	5.03	1.210	2.916	29	7.681	.502
Total	Male	8.75	4.58	1.478	3.013	31	8.590	.491
	Female	9.90	5.22	1.929	3.332	28	9.886	.518
	Total	9.30	4.89	1.722	3.194	59	9.238	.354

From Table 4, it is evident that there were apparent differences between the mean scores and adjusted means for the grades of second-year intermediate school students in the Kingdom of Saudi Arabia on the overall reading comprehension skills test for both pre-test and post-test, according to the group variable (experimental, control). To determine whether these apparent differences are statistically significant, a two-way analysis of covariance (Two WAY ANCOVA) was used for the post-test scores on overall reading comprehension skills according to the group (experimental, control) and gender after controlling for their pre-test scores. The results are presented in Table 5.

Table 5. Two-way Analysis of Covariance (2way ANCOVA) for the Post-test Scores of Second-year Intermediate School Students in the Kingdom of Saudi Arabia on the Overall Reading Comprehension Skills Test, According to the Group, Gender, and their Interaction, after Controlling for their Pre-test Scores

Source of variance	Sum of squares	df	Means of squares	F	Sig.	η2
Pre-test	44.378	1	44.378	6.163	.016	.102
Group	138.902	1	138.902	19.289	.000	.263
Gender	23.377	1	23.377	3.246	.077	.057
Gender* group	10.341	1	10.341	1.436	.236	.026
Error	388.849	54	7.201			
Total	591.684	58				

Table 5 indicates statistically significant differences at a significance level ($\alpha \geq 0.05$) in the scores of second-grade students in Saudi Arabia on the reading comprehension skills test according to the group (experimental, control). The calculated value of F (19.289) showed a statistical significance of (0.000), a statistically significant value, indicating an effect of the group. The results in Table 5 suggest that the differences favored the experimental group, who underwent an educational program based on cognitive neuroscience compared to individuals in the control group. Table 5 also shows that the effect size of the teaching method was large; the eta-squared (η2) value explained 26.3% of the predicted variance in the dependent variable, which is the reading comprehension skills test. In addition, there were no statistically significant differences ($\alpha \geq 0.05$) attributable to the gender effect, with an F value of (3.246) and a statistical significance of (0.077). Moreover, there were no statistically significant differences ($\alpha \geq 0.05$) attributable to the interaction effect between the group and gender, with an F value of (1.436) and a statistical significance of (0.236).

Discussion

The main objective of this study is to investigate the impact of an educational program based on cognitive neuroscience on developing reading comprehension skills among second-grade students in Saudi Arabia. The study results showed a statistically significant effect in favor of the experimental group, indicating that the educational program was effective in improving the level of reading comprehension among the study sample and enhancing their skills. These results can be explained by the inclusion of neuroscientifically informed reading procedures and applications in the educational program. Cognitive neuroscience provides insights into the optimal mechanisms for developing reading comprehension skills consistent with the nature of the human brain. The

program also incorporated various interactive activities, including reading processes, group work, discussions, interpretation, inference, comparison, critique, and creativity. The educational program aimed to empower students in linguistic analysis and critical thinking, improve vocabulary interpretation, extract main and supporting ideas, and create a linguistic environment that focuses on effective communication among students. It aimed to enhance students' confidence in expressing themselves and their opinions freely, develop concentration and reading alertness skills, and objectively analyze and evaluate texts. These aspects captured the students' interest and motivated them to engage in the process of developing reading comprehension skills.

In addition, the educational program included specific instructional procedures designed to develop reading comprehension skills at all four levels: literal, inferential, critical, and creative. These procedures aimed to motivate students from all achievement levels to participate in reading activities without feeling embarrassed about the errors they might make. The program encouraged irregular distribution of reading among students to keep them alert during the reading process. It leveraged collaborative work to refine their answers before presenting them to other groups. The program also emphasized using context to understand the meanings of new vocabulary, exploring the author's intentions, and supporting their opinions with evidence from the text. These instructional strategies made the educational program sequential and coherent, presented as a series of steps focusing directly on the targeted skills. This was not available in the control group, which focused on processing reading texts through reading and answering subsequent questions.

The current result can be explained by the motivational impact of the instructional procedures in the minds of the students, encouraging them to engage in the process of learning reading comprehension skills and fostering a sense of responsibility. The effectiveness may be attributed to the opportunities provided by the educational program for practicing reading processes, including inference, judgment of the text and its author, and transforming the text from one literary form to another. The program offered depth to students' interaction with the reading texts, and this had a clear impact on developing the reading comprehension skills of the study sample, as targeted by the study.

Additionally, the role played by the teachers in organizing, guiding, directing, and providing continuous support throughout the learning process and the implementation of the educational program contributed to the observed results. This result is consistent with educational literature, relevant research, and scientific studies related to the development of reading comprehension skills. These sources emphasize that reading comprehension skills can be developed when programs, methods, and teaching approaches are built on clear scientific foundations aligned with the latest findings in educational sciences. The success is also in harmony with the nature of brain-based learning, activating the role of the teacher as a supporter, facilitator, and enhancer of students' learning and language skills development, considering how their brains learn. Furthermore, these results align with those of various studies (Alshawarea & Al-Makableh, 2020; Al-hawamdeh, 2021; Alabdulaziz & Alnaanaa, 2021; Al-Ghamdi, 2020; Alawi, 2016; Alomosh & Aljohani, 2016; Fung et al., 2003; Hoffman et al., 2020; Khattabah et al., 2020; Rizk & Altoum, 2018).

In addition, there was no statistically significant difference between the average scores of male and female students

in the reading comprehension test attributable to gender and the interaction between group and gender. This result indicates that reading comprehension was not affected by students' gender, as the educational program's procedures benefited both male and female students equally. This result may be explained by the neutrality embedded in the reading texts and the educational program's procedures, as neither of them showed bias toward any gender over the other. Consequently, students engaged with them at the same level.

Conclusion

The current study represents a significant contribution to the field of reading comprehension education and skill development. Intermediate school students in the second grade have enhanced their reading comprehension skills significantly. This suggests that educators should utilize specialized educational programs based on the latest findings in cognitive neuroscience. This approach provides a clear understanding of how the human brain learns, guiding educational practices to achieve optimal proficiency in students' mental abilities. The study underscores the importance of delivering reading comprehension skills according to students' diverse and graded levels in a manner that supports a safe educational psychological environment. Results emphasize that teaching methods for reading comprehension skills should actively engage students in the learning process, with the student being the center of activity, and the teacher facilitating, guiding, and supporting rather than simply instructing. Therefore, reading sessions should be an active space where students interact with reading texts at various levels, from literal to creative comprehension.

Despite the promising results, the researchers identify several areas for future research, such as investigating the impact of movement, sleep, and healthy habits on language development in general and reading comprehension in particular. Additionally, exploring applied linguistics learning based on simulating the practices of linguists in real-life scenarios, such as critics, writers, and journalists, would establish a genuine connection between classroom learning and the linguistic activities practitioners engage in daily. The study's results were limited to the chosen sample of second-grade intermediate school students in the Kingdom of Saudi Arabia, particularly in Najran region, during the academic year 2022-2023. The study relied on the selected tool and psychometric characteristics of the educational program based on cognitive neuroscience and the reading comprehension test.

Acknowledgment

The authors are thankful to the Deanship of Scientific Research at Najran University for funding this work under the Research Priorities and Najran Research funding program, Grant code (NU/NRP/SEHRC/12/16).

References

Ahmed, S. M. (2011). The effectiveness of reciprocal teaching strategy in developing reading comprehension skills and fostering the inclination toward cooperative work among third preparatory grade students. *Sohag University Journal of Education, 29*, 205-261.

Al-Abdulaziz, K., & Al-Naanaa, I. (2021). The impact of a strategy based on beyond comprehension skills in developing reading comprehension among eighth-grade students in Jordan. *Ramah Journal for Research and Studies, (59),* 37-162.

Al-Amoush, I., & Al-Juhani, A. (2016). The impact of using the reciprocal teaching method in developing reading comprehension skills among third-grade intermediate school students in Al-Qurayyat, Saudi Arabia. *Journal of Taibah University for Educational Sciences, 11,* 1, 1-14.

Al-Attar, Z. B., & Al-Tamimi, M. (2023). The impact of the proactive guidance strategy on reading comprehension and visual thinking among first-grade intermediate school students. *Journal of the College of Basic Education, University of Mustansiriya, March*, 303–322.

Alawi, I. (2018). Neuroscience and education: Any relationship? *Journal of Educational Sciences, 64*, January, 8-17.

Al-Ghamdi, A. (2020). The effectiveness of the mental imagery strategy in developing comprehension and attitudes toward reading among sixth-grade female students. *Journal of the Islamic University for Educational and Psychological Studies, 1*(28), 252-281.

Al-Hawamdeh, M. (2021). The effectiveness of the Kitsu strategy in developing reading comprehension skills among seventh-grade students in Jordan. *Studies in Educational Sciences, 3*(48), 1-20.

Al-Rashidi, M., & Haji, K. (2021). The level of proficiency of primary school female students in reading comprehension skills from the perspective of their teachers. *Arab Journal of Science and Research, Journal of Educational and Psychological Sciences, 5*, 48, 52-86.

Al-Saidawi, K. Y. I. (2015). The impact of using the "Touch the Moon" strategy on developing reading comprehension skills among fourth-grade female students. Unpublished master's thesis, Islamic University, Palestine.

Al-Shawawreh, S., & Al-Matari, N. (2020). The impact of the electronic mind map strategy on developing reading comprehension skills among ninth-grade female students and their attitudes toward reading. *Journal of the Islamic University for Educational and Psychological Studies, 2*(29), 334-365.

Atif, Y. (2018). A proposed strategy based on integrating fragmented information and reciprocal questioning for teaching Arabic language and its impact on developing reading comprehension and literary analysis skills among third-grade intermediate school students. Unpublished doctoral dissertation, King Khalid University, Saudi Arabia.

Barnes, M. (2016). *The Five Minute Teacher: How to increase learning time in your classroom* (M. Al Jiosi, Trans.). Riyadh: Arab Bureau of Education for the Gulf States.

Duman, B. (2010). The effects of brain-based learning on the academic achievement of students with different learning styles. *Educational Sciences: Theory & Practice, 10*(4), 2077-2103.

Ellis, G. F. R., & Bloch, C. S. (2020). Neuroscience and Literacy: An Integrative View. *Preprints, 2020120139.* https://doi.org/10.20944/preprints202012.0139.v3

Fung, I. Y., Wilkinson, I. A., & Moore, D. W. (2003). L1-assisted reciprocal teaching to improve ESL students' comprehension of English expository text. *Learning and instruction, 13*(1), 1-31.

Gazzaniga, M. (2008). *Learning, Arts, and the Brain (The Dana Consortium Report on Arts and Cognition).* New York: Dana Press.

Goodman, K. S., Fries, P., Strauss, S., & Paulson, E. (2016). *Reading: The Grand Illusion. How and Why Readers*

Make Sense of Print. Routledge.

Hamedi, S. M., Pishghadam, R., & Fadardi, J. S. (2020). The contribution of reading emotions to reading comprehension: the mediating effect of reading engagement using a structural equation modeling approach. *Educational Research, Policy, and Practice, 19*(3), 211–238. https://doi.org/10.1007/s10671-019-09256-3

Hashim, A., Marz, H. A. Z., & Hussein, N. A. (2016). The extent of first-year secondary school students' proficiency in critical reading comprehension skills. *Journal of Research and Scientific Publishing, 32*(1), 1-8.

Hoffman, J. V., Hikida, M., & Sailors, M. (2020). Contesting science that silences: Amplifying equity, agency, and design research in literacy teacher preparation. *Reading Research Quarterly, 55*, S255-S266.

Javourey-Drevet, L., Dufau, S., François, T., Gala, N., Ginestié, J., & Ziegler, J. (2022). Simplification of literary and scientific texts to improve reading fluency and comprehension in beginning readers of French. *Applied Psycholinguistics, 43*(2), 485-512. https://doi.org/10.1017/S014271642100062X

Jensen, E. (2005). *Teaching with the brain in mind.* Alexandria, VA: Association for the Supervision of Curriculum Development.

Khattabah, O., Al-Saadi, E., & Mqableh, N. (2020). The impact of the dialogue circle and mental imagery strategies on the performance of eighth-grade students in reading skills. *Journal of Islamic University for Educational and Psychological Studies, 6*(28), 941-964.

Kweldju, S. (2015). Neurobiology Research Findings: How the Brain Works During Reading. *PASAA, 50*, 125-142.

Lotfallah, N. (2012). Teaching model proposed in the light of the brain-based learning for the development of academic knowledge and scientific reasoning and self-regulation in science for Seventh-grade students. *Journal of Egypt Ion Society of Science Education, 15*(3), 229-279.

Morrison, T. G., Wilcox, B. (2020). Assessing Expressive Oral Reading Fluency. *Education Sciences, 10*, 59. https://doi.org/10.3390/educsci10030059

Müller, C., Otto, B., Sawitzki, V., Kanagalingam, P., Scherer, J.-S., & Lindberg, S. (2021). Short breaks at school: effects of a physical activity and a mindfulness intervention on children's attention, reading comprehension, and self-esteem. *Trends in Neuroscience and Education, 25*, 1-10.

Perkins, K., & Jiang, X. (2019). Neuroimaging and reading comprehension. *Journal of Interdisciplinary Studies in Education, 8*(2), 74-94.

Rizk, A., & Al-Otoum, A. (2018). The impact of an educational program based on mental imagery in developing reading comprehension among seventh-grade students in Jordan. *Al-Quds Open Research Journal for Educational and Psychological Studies, 26*(9), 1-17.

Silalahi, D. E., Herman, H., Sihombing, P. S. R., Damanik, A. S., & Purba, L. (2022). An Analysis of Students' Achievement in Reading Comprehension through Higher Order Thinking Skills (HOTS). *Al-Ishlah: Jurnal Pendidikan, 14*, 1853-1868. https://doi.org/10.35445/alishlah.v14i2.1249

Silvira, Y., & Suyadi, S. (2023). Tahfidzul Qur'an based on Brain-Based Learning. *Edumaspul: Jurnal Pendidikan, 7*(1), 1-6. https://doi.org/10.33487/edumaspul.v7i1.5359

Swart, E., & Jong, M. T. Sikkema-de. (2023). The effects of increased dopamine levels on attentional control during reading and reading comprehension. *Current Psychology, 42*, 11009–11025.

Youssef, A. (2021). The impact of training on the International Student Assessment (PISA) test models in improving the performance of tenth-grade students in reading comprehension tests in the Directorate of Education in Irbid. *An-Najah University Journal for Research (Humanities), 2*(35), 199-220.

Author Information

Hala Alhag Alameen Sulieman
https://orcid.org/0009-0000-9333-2992
Assistant Professor of Education Technology, Department of Curriculum and Teaching Methods, College of Education, Najran University
Saudi Arabia
Contact email: *haalameen@nu.edu.sa*

Ibrahem Mohammed Abdullah Alamoush
https://orcid.org/0009-0007-8728-4227
Assistant Professor of Arabic Curriculum and Teaching Methods, Sharjah Education Academy
Sharjah
United Arab Emirates

Kholoud Abdulraheem Auwid Al Shdaifat
httpid.org/0009-0000-3267-1608
Associate Professor of Arabic Curriculum and Teaching Methods, Department of Arabic Curriculum and Teaching Methods, College of Education, Najran University
Saudi Arabia