

## The effectiveness of using electronic mind maps in developing creative and critical thinking skills among 9th-grade female students in the reading skill: A quasi-experimental study



Afraa Ali Al-Hosni 

Faculty of Education and Arts, Sohar University, Sohar, Oman.  
Email: [aashosni@su.edu.om](mailto:aashosni@su.edu.om)



### ABSTRACT

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#### Keywords

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This quasi-experimental study investigated the effectiveness of electronic mind maps in developing critical and creative thinking skills in reading among ninth-grade girls. The sample consisted of 62 female ninth-grade students: an experimental group (n=30) instructed using an electronic mind mapping program and a control group (n=32) instructed using conventional methods. The researcher used the pretest-posttest control-group design with an achievement test developed and validated for creative thinking skills (e.g., generating synonyms, suggesting titles) and critical thinking skills (e.g., distinguishing fact from opinion). Independent and paired sample t-tests showed statistically significant differences ( $\alpha=0.05$ ) in the posttest scores favoring the experimental group across all skills considered, with a large effect size ( $\eta^2=0.26$ ). The experimental group also showed significant improvement between pretest and posttest scores. It can be concluded that electronic mind mapping is highly effective in developing these higher-order thinking skills in reading. Recommendations include redesigning the reading curriculum to integrate digital tools such as mind mapping and implementing one day of virtual schooling a week. Future research should include the effectiveness of mind mapping for other language skills and descriptive studies of its current usage for teaching Arabic. In addition, descriptive studies are recommended to determine and investigate the current uses and adoption rate of the educational and electronic mind map program within the Arabic language curriculum and educational context.

**Contribution/ Originality:** This study is original in that it simultaneously examines the integrated development of creative and critical thinking skills in reading through electronic mind maps, rather than addressing each skill separately. It also provides empirical evidence from a quasi-experimental design within Arabic language instruction for ninth-grade female students.

### 1. INTRODUCTION

Reading is one of the basic tools for learning and studying, and for cognitive growth and development, especially because a greater percentage of facts and information gathered is gained from reading, regardless of whether the documents are hard copies or online [1].

Reading is the process involving the recognition of symbols by perception, articulation through reading aloud, and the ability to comprehend while reading. It consists of interpreting symbols and relating them to reality while reading and applying them accordingly [2]. The process and achievement of understanding reading meanings require reading comprehension, which is one of the most vital skills for reading and a primary goal of teaching reading.

Reading is inherently and fundamentally interconnected with reading comprehension [3]. Thus, learners should be taught the skills and methods necessary for reading a text with the intention of gaining a higher level of understanding and grasping various aspects of a subject, employing reading strategies and methods for reading with a focus on comprehension [4].

Reading is often emphasized among language skills owing to its functional aspects, given that reading is a critical component of the overall language skills system. Language skills include listening, speaking, reading, and writing. These represent the four pillars of linguistic communicative functions [5]. A skilled listener is often a skilled speaker and reader, while a skilled reader is preferably a skilled speaker and writer. It is argued that this perception aids integration and prevents separation and fragmentation among language skills [6]. Emphasis on reading is owing to its functional aspects, such as providing the acquisition of knowledge and offering avenues for intellectual and cognitive growth by providing access to all possible experiences. Reading is preferably given much more emphasis compared to other language skills because it provides a basic support system on which all other skills meet and hinge for growth and development [7]. Figure 1 illustrates the connection between reading and the other language skills.

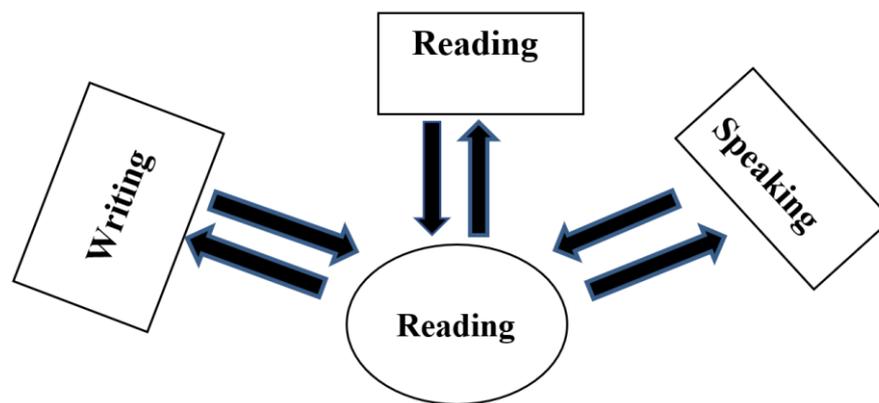


Figure 1. The connection between reading and the other language skills.

The researcher asserts that the process of language acquisition and development is cumulative, though the nexus between reading and other language skills is one of interaction and influence. The process of listening skills' development and enhancement occurs through reading, and reading is developed and elevated through support from other language skills. Reading provides learners with a broad vocabulary, meanings, and ideas that are simple and complex, and range from explicit to implicit. As the student continues reading and applying all other language skills available for support and development, their language repertoire increases and develops, and this helps them to perform well and fluently while speaking. As learners apply vocabulary, meanings, and ideas from reading while speaking, they perform functional tasks that facilitate understanding and encourage learners to distinguish between the suitable expressions and grammatical structures to be used within the context. As all language skills are constantly and persistently applied by students, their thinking develops and matures. In general terms, thinking is referred to as the process whereby learners find meaning within a particular context and experience. The activities carried out and engaged by the person, whether visible and overt or invisible and hidden, and whether expressed orally and written, are the result and product of this process referred to as thinking. As such, the process and concept referred to as thinking has recently assumed the educational agenda as part and parcel within contemporary educational reform.

### 1.1. Problem Statement

In this research, the effectiveness of using electronic mind maps is examined for developing creative and critical thinking skills among female ninth-grade students in reading.

### 1.2. Research Questions

The current study aimed to investigate the impact of using mind maps in promoting creative and critical thinking skills among 9th-grade female students in reading skills. Accordingly, it sought to answer the following questions:

1. What impact does the use of mind maps have on promoting creative and critical thinking skills in reading among 9th-grade female students?
2. Are there any significant differences between the mean scores on the posttest for experimental and control groups on the reading-based test of creative and critical thinking at the 0.05 level of significance ( $\alpha \leq .05$ )?

### 1.3. Objectives of the Study

The current study targets the following objectives.

- To identify and validate a list of creative and critical thinking skills in the reading skill suitable for 9th-grade female students.
- To design reading lessons that focus on developing creative and critical thinking skills in alignment with the application of electronic mind maps.
- To investigate the effectiveness of using electronic mind maps in developing creative and critical thinking skills among 9th-grade female students in reading skills.

### 1.4. Significance of the Study

The relevance of this research can be understood on multiple significant dimensions. This research can help designers and developers design improvements in curricula with the help of electronic applications for enhanced learning outcomes. In addition to this, this research can support alignment with the digital revolution and can accurately meet the criteria for e-learning. Furthermore, this research can help teaching professionals design a class with the inclusion of electronic mind maps as instructional aids. Finally, this research can help design a testing tool for the evaluation of creativity and critical thinking while reading on multiple dimensions.

### 1.5. Limitations

The study is limited within particular constraints on multiple aspects, namely, on the human, geographical, and time dimensions. The study focuses on a sample population consisting of ninth-grade students studying basic education. The study was conducted within the boundaries of the Al-Batinah North Governorate. Additionally, the study was implemented during the second semester of the academic year 2022-2023. Further, the study was limited to the reading class scheduled for ninth-grade students during this semester, with a focus on developing creativity and critical thinking through reading.

### 1.6. Definitions of Terms

- **Electronic Mind Maps:** A program used for creating mind maps, illustrative diagrams, and visual representations, applied by 9th-grade female students to perform activities that develop their creative and critical thinking skills in reading, as defined in the present study.
- **Creative thinking skills in reading:** A set of cognitive processes and practices normally used by grade nine students while reading. This set includes generating the largest possible list of synonyms from contextual cues, suggesting several antonyms for a given word, identifying significant terms from the text, distinguishing between the central idea and supporting details in a text, interpreting the lessons taught by the text, suggesting suitable headings for the sections or text, and generating a list of questions relating to the content of the paragraphs.
- **Critical thinking skills and activities exercised by ninth-grade students while reading:** Skills and activities such as distinguishing facts from opinions, developing an evaluative stance with respect to the given ideas and issues,

identifying cause-and-effect relationships among the given ideas and issues, and developing consequences based on actual and hypothetical causes.

## 2. LITERATURE REVIEW

Language and its associated skills can be referred to as a thinking tool. It is through this tool that various thinking operations, such as explanation, analysis, comparison, recognition of relationships, inference, abstraction, and generalizations, can be carried out. In terms of effective expression of ideas, the process of explanation must be carried out from a clear form of thinking that is dependent on language. It is therefore important for language instruction to focus on language skills and thinking processes, such as thinking, understanding, explanation, and creativity [3].

Creativity, in turn, is a process that requires extensive practice and training for the student to reach an advanced level in reading. Shahatah [1] defines creative thinking in reading as the interaction between both the reader and the text, in which the student relies on the information provided within the text and on prior knowledge, linking both to generate new ideas, meanings, and applicable conclusions, as well as demonstrating the ability to ask explicit and implicit questions about the text's information.

According to educational literature, creative thinking in reading includes a number of skills that have been discussed collectively by several specialists and educators, such as Shahatah [1]; Sbeitan [8]; Salah and Al-Mahboub [9] and Salah [10]. The researcher summarized these skills as follows: adding new ideas to the text being read, identifying the missing elements within the text, and posing thought-provoking questions related to the text at the end of reading. It also involves applying the ideas and facts extracted from the text to new situations, suggesting several future applications based on the reader's reflections, predicting the events that the text may include through the information presented to the reader, and creating multiple solutions from various sources for the problem presented in the text [2]. In addition, it includes proposing appropriate titles for the text, expressing the content through new creative productions such as a short play, a poem, a story, or a wise saying, suggesting alternative endings to the topic from the reader's imagination, and summarizing the text accurately without distortion.

Al-Harbi, et al. [6] point out that several obstacles hinder the development of creative thinking in the classroom. The most prominent of these is the reliance of classroom learning methods on rote memorization and repetition, through traditional teaching approaches, achievement tests, and drills and activities that limit higher cognitive thinking skills, which might include analyzing, synthesizing, and evaluating on input. In this regard, Rahma [11] carried out a literature review and focused on the relevance of Bloom's Taxonomy on educational objectives for enhancing creative and critical thinking skills among students from Malaysia. In this review, it was indicated that there was a lack of emphasis on advanced stages of learning in current educational approaches. This is responsible for the reduced capacity among students to apply higher-stage thinking abilities.

Critical thinking is described as "responsible thinking that facilitates the process of making judgments or decisions based on specific criteria, relying on the learner's self-evaluation and sensitivity to the situation and its elements" [12]. It involves various skills such as argument analysis and evaluation, formulation of inferences from either inductive or deductive processes, formulation of judgments and evaluation, decision-making, problem-solving, and finding causes and effects [13]. Further, critical thinking skills include the ability to distinguish between fact and opinion, as well as the ability to evaluate ideas and conclude from given facts, determine concepts for acceptance and rejection, and infer particular observed facts, according to Al-Shammari and Al-Rasheed [14].

With the continued growth of knowledge and advancements at a remarkably accelerated pace within the current era, the twenty-first century requires learners to be equipped with innovative and critical thinking skills. This necessitates teaching students how to learn, think, and apply their knowledge outside the classroom. However, this learning process is limited by some Arab countries' educational systems, despite evidence that thinking can be developed similarly to other subject areas, such as facts and concepts, at a similar rate, by applying specific approaches and programs that develop thinking skills [12]. Additionally, there is a noticeable regression in the advancement and

development of innovative and critical thinking skills within some educational institutions across Arab nations. Some factors responsible for this regression include the continued adoption and use of traditional teaching approaches and practices by educators within educational settings today [13].

From the experience gathered from teaching and supervising by the researcher, developing skills for innovative and critical thinking requires intense attention and support. This is due to various considerations such as the lack of knowledge on the part of tutors regarding approaches for developing such skills within the curriculum content, the lack of use of diagrams and concept maps within instructional materials for the purpose of training students on such aspects, and the time and energy required for the preparation and design of activities within the curriculum content to influence the ability to give prominence to developing such critical skills.

Consequently, the idea emerged to employ electronic mind maps as an instructional tool to train students in these skills. The concept of using mind maps in teaching through educational content originated with Schwartz, et al. [15] at Boston University (USA). These mind maps are structured, graphical representations used as tools to enhance thinking and promote deep learning of content. Learners use them to explore educational topics, stimulating their abilities in inquiry, reflection, and decision-making to solve problems [16].

Abdul-Basit [4] defines electronic mind maps as “creative and spontaneous diagrammatic representations based on specialized computer programs, consisting of branches radiating from a central point using lines, words, symbols, and colors. They are used to represent relationships between ideas and pieces of information and require spontaneous thinking during their creation.”

Salama, et al. [17] explain that the Mind Maps program is electronic computer-based software operating within the Windows environment. It includes all necessary tools, lines, images, symbols, and shapes that facilitate the precise and standardised drawing of mind maps, forming the foundation of electronic mind map design. Electronic mind maps benefit in various ways, as outlined by Campbell and Chittleborough [18], Marvin and Bill [19] and by Al-Shaniqat [20]. The benefits include simplifying and organizing information for easy retrieval, connecting ideas that can be related to one another, speeding up the thinking process for quicker decision-making, stimulating the generation of ideas for innovation and brainstorming activities, and improving learning processes to be more fascinating and effective.

In addition to that, the study highlights more advantages of this tool. For instance, the ability to add or remove information and the ability to accordingly develop the structure/layout to meet the preferences and type of content delivered to the learners constitute additional advantages. In this regard, the study was carried out by Al-Bayaydah [21]. The study found significant differences between the seventh-grade female students' creativity and the Arabic subjects they were studying based on the teaching method (concept maps) between the experimental and the control groups. Also, Hussein, et al. [22] carried out research focused on enhancing the skills of first-grade intermediate students to be creative thinkers using the application of electronic mind maps. The results proved that the application of electronic mind maps is effective in developing creative thinking skills.

In addition, the study was conducted by Al-Hawari [23] to investigate the impact of both electronic and manual mind maps on enhancing critical thinking skills among female students from the Department of Early Childhood. Both groups demonstrated a significant impact when using electronic and manual mind maps.

A study was conducted by Jaradat and Al-Abadi [24] to explore the impact of electronic mind maps on the development of reading comprehension skills among grade 9 students within Arabic language classes. A sample for the study included 30 participants in the control group and 30 in the experimental group. The results showed a significant mean difference in achievement test scores in favor of the experimental group. The research was triggered by the apparent reduction observed within educational literature regarding training learners in creative and critical thinking skills, as well as personal observations of the considerable lack of emphasis on such skills within the educational field. This research is based on previous studies undertaken by various scholars, such as Al-Bayaydah

[21]; Hussein, et al. [22]; Al-Hawari [23] and Jaradat and Al-Abadi [24], among others, which proved the effectiveness of certain approaches and initiatives aimed at developing such skills among learners.

Further, these studies propose the use of a prompt for Arabic language teachers to design activities and tasks for their students based on the mind map approach due to the various advantages this approach provides for developing students' creative thinking skills. It is with these findings and proposals that the current study was informed and sought to investigate the effectiveness of the use of electronic mind maps on developing creative and critical thinking skills for ninth-grade female students [25].

The enhancement of the processes of creative and critical thinking is one of the basic aims laid down for education at the beginning of the 21st century and is still a significant educational task nowadays. Moreover, developing these skills is a significant issue within the framework of language education. "Creative thinking in reading is a process involving interaction between the reader and text information with a view to creating fresh notions and applying them for the first time by combining text information with prior knowledge" [1]. Critical thinking is understood as a "kind of decision-making process based on evidence and criteria" [12], critical thinking involves "skills such as discrimination between facts and opinions, argument analysis, and detecting cause and effect" [26], nowadays, this process has been distinguished and renovated by identifying the differences between facts and opinions, exploring arguments, and detecting cause and effect among them [14]. Despite the general agreement on the significance and necessity of developing critical and creative thinking skills at educational establishments worldwide and within the Arab States, reliance on traditional methods and approaches, along with constraints posed by educational curricula, hinders progress. However, the gap between theory and practice has created a longing for more innovative approaches to learning and teaching methods. Electronic mind maps are one such approach that can be utilized to address this issue. Mind maps can be defined as nonlinear computer diagrams that structure various ideas around a central subject [4, 27]. Mind maps use visualisation to organise complex ideas [18, 19]. The interactive and dynamic properties possessed by mind maps can thus make them suitable for developing thinking skills that traditional methods normally overlook. However, current empirical studies form a preliminary yet informative background for this potential and expose a fragmented and limited-scope evidence base. The literature searches confirm the existence of several positives: for instance, Al-Bayaydah [21] proved that the concept map can increase Arabic creative thinking among seventh-grade students, while Hussein, et al. [22] found similar increases for middle-grade students and with the use of electronic mind maps for creative thinking. In addition, Jaradat and Al-Abadi [24] correlated the use of electronic mind maps with increased reading comprehension for ninth-grade Arabic classes. However, critical analysis throws light upon two important limitations.

First, prior studies typically examined creative thinking [22, 23] or critical thinking rather than investigating their integrated development within a single approach. Second, there was a shortage of studies focusing on the integration and simultaneous development of creative and critical thinking within the reading curriculum. As such, while there is evidence supporting the application and benefits of mind maps and mind mapping software from prior research and practice, there is still a research gap here.

It is precisely this gap that this research aims to fill by exploring the application and impact on reading scenarios specifically involving the use of interactive online mind maps on the simultaneous development of both creative and critical thinking skills among ninth-grade students.

### **3. METHODOLOGY**

#### *3.1. Research Design*

This study followed a quasi-experimental research design. This approach involves selecting two groups: a control group and an experimental group. The control group consisted of 32 female participants, while the experimental group comprised 30 female participants.

### 3.2. Participants

The study population consisted of all ninth-grade female students enrolled in public basic education schools under the governance of the Governorate of Al-Batinah North for the year 2022/2023. The two girls' basic education schools were purposively sampled because they were under the same administrative district. Additionally, two intact classes from the sampled schools were randomly assigned to the experimental and control groups.

The final sample included 62 ninth-grade female students from the Al-Noor Basic Education School for Girls: one experimental ( $n = 30$ ) and one control ( $n = 32$ ) group. In this research, all participants were ninth-grade female students aged around 14-15 years and were studying under the national standard curriculum at the time of this research. To identify whether there is any significant mean difference between the two groups on pretest scores on the skills for creative and critical thinking, the independent-samples t-test was carried out and showed no significant differences ( $p > 0.05$ ); thus, equal baseline values were achieved (see Table 3).

### 3.3. Instruments

- An 11-skills list consisting of two main domains: creative thinking (7 skills) and critical thinking (4 skills).
- It was created with 15 items forming the achievement assessment centered on the list of skills (see Table 1). It included a mix of objective items (both multiple-choice for identifying keywords and constructed responses for creating synonyms, title suggestions, and forming an opinion).
- The instructional content included all eight reading lessons for ninth-grade students designated for the second semester. The researcher adapted all eight reading lessons to be aligned with activities utilizing the Mind Maps electronic mind map software to develop skills for creative and critical thinking, identified here as the primary variable for this study.
- Rubric for scoring: A detailed analytic rubric was created for the constructed response items with the intention of objectivity and reducing bias. For instance, for tasks such as 'generate synonyms for the given definitions,' the scores depended on the number of contextually fitting synonyms provided. Conversely, for 'suggested title' tasks, the criteria included relevance to the central idea and creativity.
- Scoring and Inter-Rater Reliability: To promote reliability while scoring the subjectively constructed-response items, the researcher and a second expert separately scored a random sample containing 20% of the pre- and post-tests. Inter-rater reliability was calculated by employing Cohen's Kappa statistic. The result was found to be 0.88, which is a very reliable measure as far as inter-rater reliability is concerned. The differences were later cleared by discussion among the raters, and then the researcher marked the rest of the tests on the basis of the rubric developed.

### 3.4. Validity and Reliability

- Validity: A list of skills and achievement tests was judged by a panel of 12 curriculum and instruction experts. The inclusion of feedback guarantees content validity.
- Reliability: Internal consistency for the overall test was estimated using Cronbach's Alpha on a pilot sample ( $n = 30$ ), and a high reliability coefficient ( $\alpha = 0.90$ ) was found. The sub-factors were found to be reasonably reliable ( $\alpha = 0.86$  for the Creative Thinking sub-factor and  $\alpha = 0.70$  for the Critical Thinking sub-factor). Interpreter reliability for subjective items was given as  $\kappa = 0.88$ .
- Instructor Variability: To equalize teacher variability, the researcher conducted the study while acting as the instructor for all participants under treatment and control, thereby equalizing variability due to differences in instructional style and bias.
- Intervention: In this intervention, the experimental participants were exposed to remodeled learning activities through mind maps for 18 sessions, while the other participants were exposed to the same content using the normal method. The intervention lasted from March 12 to May 30, 2023.

The researcher adopted these recommendations, and the final version of the skills list was established as presented in Table 1.

**Table 1.** List of creative and critical thinking skills and the test items representing them.

Level of thinking	Skill	Test item number
Creative thinking	Generating the largest possible number of synonyms for a word from context	(1, 2)
	Generating the largest possible number of antonyms for a word	(3)
	Identifying the key words in the text	(4)
	Distinguishing between main and supporting ideas	(5, 6)
	Inferring the lessons learned from the text	(7)
	Suggesting appropriate titles for the text	(8)
	Asking diverse questions related to the paragraph content	(9)
Critical thinking	Distinguishing between fact and opinion	(10)
	Forming an opinion about the presented ideas and issues	(11)
	Identifying cause-and-effect statements	(12)
	Generating results or consequences based on actual or hypothetical causes	(13, 14, 15)

The researcher developed an achievement test based on the list of creative and critical thinking skills, validated it through expert review, and tested its reliability, as shown in.

To determine the reliability of the test for the Creative and Critical Thinking Skills Test, the study was conducted on a pilot sample of 30 students (male and female). Cronbach's Alpha coefficients for all the dimensions and for the entire test were calculated. Table 2 highlights the result.

**Table 2.** Cronbach's alpha reliability coefficients for the creative and critical thinking skills test in reading.

Test dimensions	Number of items	Cronbach's alpha coefficient
Creative thinking	9	0.86
Critical thinking	6	0.70
Total test	15	0.90

It is evident from Table 2 that the Cronbach's Alpha coefficients for the dimensions of the Creative and Critical Thinking Skills Test in Reading ranged between 0.70 and 0.86, while the overall reliability of the test reached 0.90. These values indicate that the test possesses an acceptable and high level of reliability.

- After confirming its reliability, the test was applied as a pretest to both the experimental and control groups. The researcher then verified the equivalence of the two groups, and the results of this verification are presented in Table 3.
- Equivalence of the groups: To ensure the equivalence between the experimental and control groups in the pre-measurement of higher-order reading skills, an independent samples t-test was conducted. The results are shown in Table 3.

**Table 3.** Results of the independent samples t-test for differences between the experimental and control groups in the pretest.

Variables	Group	N	Mean	SD	t-Value	df	Sig. ( $\alpha$ )
Creative thinking	Control	32	6.81	3.55	0.77	60	0.444
	Experimental	30	7.53	3.81			
Critical thinking	Control	32	4.75	3.03	0.54	60	0.588
	Experimental	30	5.23	3.93			
Total thinking skills	Control	32	11.56	5.88	0.72	60	0.475
	Experimental	30	12.77	7.27			

It is evident from Table 3 that there are no statistically significant differences between the experimental and control groups in the pretest of the creative and critical thinking skills in reading, as the probability ( $p$ ) values for the t-test were greater than the level of significance ( $\alpha = 0.05$ ). Therefore, it can be concluded that both groups were equivalent in the pre-measurement of the study variables.

### 3.5. Procedures

- After confirming the validity and reliability of the study instrument, a pretest was administered to both the experimental and control groups.
- The implementation of the experimental procedure began with the experimental group, where:
- The reading lessons were designed in light of the identified creative and critical thinking skills.
- The Mind Maps program was installed on the school computers.
- The students were trained to use the program through individual and group workshops conducted over two class periods.
- The eight reading lessons were then implemented, with two sessions per lesson, each lasting 45 minutes, in addition to the two training sessions on how to use the program, totaling 18 class sessions.
- The experimental procedure started on March 12, 2023, and concluded on May 30, 2023.
- Finally, the posttest of the study instrument (Creative and Critical Thinking Skills Test in Reading) was administered to both the experimental and control groups.

### 3.6. Statistical Analysis

The researcher employed several statistical methods to analyse the study results, as follows:

- Cronbach's Alpha Coefficient: Used to verify the reliability of the study instruments.
- Independent samples t-test: used to determine the significance of differences between the experimental and control groups in the posttest of the study instrument.
- Paired Samples t-Test: Used to examine the significance of differences between the pretest and posttest for the experimental group in the mean scores obtained on the study instrument (Creative and Critical Thinking Skills Test in Reading for 9th-grade female students).

## 4. RESULTS

### 4.1. Results of the First Question

The first question tested the presence of any statistical differences in the post-test of creative and critical thinking skills in reading between the experimental and control groups.

To verify the validity of this hypothesis, the Independent Samples t-Test was used, and the results are presented in Table 4.

**Table 4.** Results of the independent samples t-test for the significance of differences between the experimental and control groups in the posttest of creative and critical thinking skills.

Dimension	Group	N	Mean	SD	t-value	df	Sig. ( $\alpha$ )	Effect size ( $\eta^2$ )
Creative thinking	Control	32	10.75	4.81	5.51	60	0.000	0.34
	Experimental	30	18.77	6.56				
Critical thinking	Control	32	6.88	3.05	2.51	60	0.015	0.09
	Experimental	30	9.20	4.20				
Total creative and critical thinking skills	Control	32	17.63	7.09	4.61	60	0.000	0.26
	Experimental	30	27.97	10.38				

Table 4 reveals the existence of apparent differences between the experimental and control groups in the posttest of the creative and critical thinking skills test. Referring to the mean scores, it is clear that the differences were in

favor of the experimental group across both sub-dimensions and the overall scale. The effect size for the total score of the creative and critical thinking skills test reached 0.26, which indicates that the impact of the Mind Map program on developing these skills among 9<sup>th</sup>-grade female students was large, according to Cohen [28] classification, which considers an effect size greater than 0.14 as large.

#### 4.2. Results of the Second Question

The second question tested whether statistically significant differences exist between the mean scores of the pretest and posttest of the creative and critical thinking skills test in reading among the experimental group students.

To verify this question, the means and standard deviations of the pretest and posttest scores for the experimental group were calculated. To determine the significance of the differences between the mean scores, a paired samples t-test was used. The results are presented in Table 5.

**Table 5.** Results of the paired samples t-test for the significance of differences between the pretest and posttest for the experimental group in the creative and critical thinking skills test in reading.

Variables	Measurement	N	Mean	SD	t-value	df	Sig. ( $\alpha$ )	Effect size ( $\eta^2$ )
Creative thinking	Pretest	30	7.53	3.81	13.67	29	0.000	0.87
	Posttest	30	18.77	6.56				
Critical thinking	Pretest	30	5.23	3.93	6.37	29	0.000	0.58
	Posttest	30	9.20	4.20				
Total creative and critical thinking skills	Pretest	30	12.77	7.27	11.69	29	0.000	0.82
	Posttest	30	27.97	10.38				

From Table 5, there is a significant difference between the pre-test and post-test for the experimental group on the overall measure and all sub-factors for creative and critical thinking skills. The Eta-squared estimates range between 0.58 and 0.82. According to Cohen [28], this is a large effect size. It is therefore suggested that there is an impressive increase in the experimental group students' ability to apply the above skills after being subjected to the Mind Map program, which is highly effective for developing these skills.

The findings from this study affirm the efficiency and impact of the Mind Map program in developing and enhancing skills for innovative and critical thinking while reading. These aspects can be ascribed to the application of the e-learning platform that meets the interests and needs of students and is consistent with the requirements and needs of the current digital age and epoch. Additionally, the interactive capabilities and uses of various diagram types (circular, tree diagram, and fishbone diagram) helped create a dynamic and interactive environment for learners. Moreover, the capacity for colour modification allowed students to make their maps personal, thus enhancing engagement. It is important to add that the application of a range of activities and tasks that vary from typical teaching practices and complement both personal and collaborative learning methods was critical. Additionally, employing various methods for reinforcing student behaviour, such as tangible rewards, the use of stickers, and praise, was important for the students' retention and motivation.

The application of interactive whiteboards and display screens for presentation and discussion among students on their work enabled collaborative feedback for all learners. The process and platform for presentation and discussion among students on their mind maps enabled collaboration and higher-order thinking.

In line with the above-mentioned finding, the current study validates the conclusion made by research from Al-Harbi, et al. [6] and Al-Abbadi and Jaradat [29], which found the efficiency of electronic mind maps in developing creative thinking skills among grade one intermediate students. Supporting this finding, research by Al-Bayaydah [21] and Al-Qatiti [30] indicates that there are differences in creating and managing creative thinking among seventh-grade female students, with a preference for the experimental group using concept maps during Arabic language learning.

The results support the findings made by Al-Hawari [23], who found that both manual and electronic mind maps can play an important role in developing critical thinking abilities among students studying at the early childhood educational stage. In this regard, the current research study supports similar findings made by Al-Safasfa [2], which proved the efficiency of using electronic mind maps to enhance creative thinking abilities among female ninth-grade students in the Gaza Governorate. Moreover, this research supports the findings of Jaradat and Al-Abadi [24], who observed significant differences between the mean scores of the experimental and control groups after applying a training method involving electronic mind maps for reading comprehension among ninth-grade students studying Arabic language.

## 5. RECOMMENDATIONS

On the basis of the findings from the study, several proposals were made with the aim of improving the learning process. These proposals included the recommendation for the modification of the reading curriculum for grade nine students to be more aligned with the current era and educational needs. Online school education for one day a week was also recommended based on the realities and needs for educational transformation and innovation, and potential educational advancements. In addition, the integration and use of the electronic mind map software program should be made obligatory for the training process for Arabic language teachers due to the proven and significant benefits of the Mind Map program for developing critical thinking in students. Moreover, offering free access to educational software and applications among students was recommended through collaboration with telecommunications companies such as Omantel and Ooredoo. To investigate the effect and impact of such educational software and applications on the development process among students, quasi-experiment studies were recommended on the Mind Map program to determine its effect and impact on developing critical and innovative thinking within the context and framework of various language skills. In addition, descriptive studies were recommended to determine and investigate the current uses and adoption rate of the educational and electronic mind map program within the Arabic language curriculum and educational context.

### 5.1. Originality Statement

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person, except where due acknowledgment is made in the text."

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**Institutional Review Board Statement:** This study was approved by the Institutional Review Board of Sohar University, Oman, under protocol number (UEB 2026-SUStaff-20), dated 29 December 2025. Informed verbal consent was obtained from all participants, and all data were anonymized to protect participant confidentiality.

**Transparency:** The author states that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.

**Competing Interests:** The author declares that there are no conflicts of interest regarding the publication of this paper.

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