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NETWORK THINKING AMONG FIFTH-GRADE PREPARATORY STUDENTS

O PENSAMENTO EM REDE ENTRE ALUNOS DO 5º ANO DO ENSINO FUNDAMENTAL

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Abstract
Network thinking skills are essential for success in several fields, as they contribute to solving complex problems by developing students' ability to analyze them, understand the relationships between them, and view them comprehensively and holistically to arrive at specific facts that contribute to acquiring information and experience, fostering innovation in completing assigned educational tasks, and working towards achieving desired goals. (Abdulrahim, 2024: 251). The current research aims to identify the level of network thinking among fifth-grade preparatory students, and the statistically significant differences at the significance level of (0.05) according to the variables of gender (male - female) and specialization (scientific - literary) among fifth-grade preparatory students in Kirkuk Governorate. To achieve this, the two researchers built a network thinking scale based on Markel's definition, which consists of three domains. To extract the results, the two researchers applied the scale to (100) male and female students. The results showed that the level of network thinking among fifth-grade preparatory students is low. No significant differences were found based on gender (males vs. females) or specialization (scientific vs. literary) at a significance level of 0.05 among fifth-grade preparatory students in Kirkuk Governorate. At the end of the study, the researchers presented a set of recommendations and suggestions based on the findings.

Keywords: Network Thinking. Fifth-Grade. Preparatory Students.

Resumo
As habilidades de pensamento em rede são essenciais para o sucesso em diversas áreas, pois contribuem para a resolução de problemas complexos ao desenvolver a capacidade dos alunos de analisá-los, compreender as relações entre eles e enxergá-los de forma abrangente e holística, a fim de chegar a fatos específicos que contribuam para a aquisição de informações e experiências, promovendo a inovação na realização das tarefas educacionais atribuídas e trabalhando para alcançar os objetivos desejados. (Abdulrahim, 2024: 251). A presente pesquisa tem como objetivo identificar o nível de pensamento em rede entre alunos do quinto ano do ensino preparatório e as diferenças estatisticamente significativas no nível de significância de (0,05) de acordo com as variáveis de gênero (masculino – feminino) e especialização (científica – literária) entre alunos do quinto ano do ensino preparatório na província de Kirkuk. Para isso, os dois pesquisadores construíram uma escala de pensamento em rede baseada na definição de Markel, que consiste em três domínios. Para extrair os resultados, os dois pesquisadores aplicaram a escala a (100) alunos do sexo masculino e feminino. Os resultados mostraram que o nível de pensamento em rede entre alunos do quinto ano do ensino preparatório é baixo. Não foram encontradas diferenças significativas com base no gênero (masculino vs. feminino) ou na especialização (científica vs. literária) em um nível de significância de 0,05 entre os alunos do quinto ano do ensino preparatório na província de Kirkuk. Ao final do estudo, os pesquisadores apresentaram um conjunto de recomendações e sugestões com base nas conclusões.

Palavras-chave: *Pensamento em Rede. Quinto Ano. Alunos do Ensino Preparatório.*

1 PROBLEM OF THE RESEARCH

We live in a world whose intricate processes have always been difficult for our human minds to comprehend. This includes the complex networks and interactions between natural forces, the enormous increase in human population density, and the subsequent sharp and escalating interventions in the natural balance and quality of human life through technological advancements. These interactions have intensified to such a degree that understanding them becomes increasingly challenging. (Fester, 1999: 9)

Therefore, network thinking skills are essential for success in many fields, as they contribute to solving complex problems. Network thinking is based on identifying interconnected relationships and interactions between the parts of the problem to be solved, and it has become necessary for students to go beyond simply acquiring information and to become productive thinkers. (Suwaidan, 2023: 192) Based on the researchers' awareness and knowledge of sources that emphasize the importance of adolescence, characterized by the rapid and significant development of all an individual's physical and intellectual characteristics, the attention given to adolescents by educational institutions should encompass all aspects of their education. This includes fostering their thinking skills and not focusing solely on academic achievement, as academic achievement represents only one facet of their diverse lives. Given the multitude of subjects and the general complexity of life, it is essential to introduce a type of thinking that aligns with this complexity: network thinking. This helps students connect what they learn in the curriculum with real-world applications.

Their life reality helps them solve their problems in a more controlled way, in addition to all the scientific evidence mentioned above about this thinking and the results resulting from it, which calls for conducting a scientific study of network thinking.

Therefore, the current research problem can be focused on the following question:

- To know the level of network thinking among fifth-grade preparatory students in Kirkuk Governorate? This question represents the problem of the current research that

prompted the two researchers to try to determine the degree of network thinking among them.

2 RESEARCH IMPORTANCE

Thinking is one of the most important topics in psychology, and its various patterns contribute to shaping personality traits. Therefore, it can be considered a source of individual differences. Since students differ in their creative abilities and academic performance, thinking is considered one of the most important psychological and cognitive topics that has garnered the attention of scientists and researchers through research, study, and experimentation. (Kamal, 2023: 35-37)

The importance of network thinking is logical and undeniable, but the question is why it is often implicitly studied and applied across a wide range of disciplines, while rarely taught as an explicit methodology. The answer lies, among other things, in the fact that so-called systematic approaches appear relatively complex and academic, and consequently, many solutions are complex and can only be implemented after extensive training. (Martin, 2019: 1)

Therefore, teaching and training in it is a priority for those who view thinking as a fundamental process for exercising students' minds and increasing the flexibility of their thinking.

Based on the above, the importance of the current research can be summarized as follows:

1- Shedding light on network thinking, which is one of the modern concepts in the field of educational and psychological specialization. It is one of the important variables that needs more experimental research, given the scarcity of research that has addressed this variable, according to the researchers' knowledge. Therefore, this study may enrich the Arabic library in this field.

2- Providing important information and facts about how to deal with students who are found to have weaknesses in network thinking.

3- The importance of the adolescent stage and its equivalent for students in the preparatory stage, which is a critical stage with its physical, social, cognitive and

emotional characteristics, as this stage leaves an important and fundamental impact on the life of the student in particular and society in general.

4- The possibility of educational researchers benefiting from this study to provide better services to students in the preparatory stage, by developing educational and developmental strategies and programs that direct their energies towards better learning.

2.1 Aims of the research

The current research aims to:

1- Measure the level of network thinking among fifth-grade secondary school students in Kirkuk Governorate.

2-Determine the statistically significant differences at the 0.05 significance level according to the gender variable (male-female) in the level of network thinking among fifth-grade secondary school students in Kirkuk Governorate

3- Identifying statistically significant differences at the significance level of (0.05) according to the specialization variable (scientific - literary) in the level of network thinking among fifth-grade preparatory students in Kirkuk Governorate.

2.2 Limits of the research

The current research is limited to fifth-grade preparatory students of both genders (males - females) and of the two branches (scientific - literary) within the schools of the Kirkuk Governorate Center for the academic year (2025-2026).

2.3 Definition of the terms

2.3.1 First: network thinking

Defined by:

1 – (Merkel 2012)

The individual's ability to process information through the interaction of the three mental processes of differentiation, discrimination, and integration. That is, their ability to perceive the number of main dimensions in a situation, to make precise distinctions within each dimension, and then to link the different dimensions in an integrated way. Through this interaction, the degree of organizational structure of the individual's cognitive system becomes apparent.

2- (Merkel, 2012:30)) swedan (2023)

It is a way of thinking that relies on drawing systematic maps of the relationships between elements through their common and relative characteristics, in other words drawing adjacent attributes in network diagram models. (Suwaidan, 2023: 194)

3 - Becker, Obergfell (2024)

It is a type of thinking in which situations and problems are not viewed in isolation from one another in terms of their individual factors, but rather through their interconnected internal relationships and their connections to other subjects. Instead of viewing the situation or problem as merely fixed, potential developments and changes are also taken into account. (Becker, Obergfell: 2024:6)

2.4 Theoretical definition

The two researchers adopted the definition of (Merkel 2012) as a theoretical definition upon which they based the construction of the network thinking scale.

2.4.1 Operational definition

The total score obtained by students through their answers to the items of the Network Thinking Scale, which was developed for the purposes of the current study based on the theory of cognitive complexity

(Preparatory Stage) -2

The Ministry of Education (2010) defined it as a three-year stage of secondary education, following intermediate school. Its aim is to consolidate students' discovered abilities and inclinations, enabling them to reach a higher level of knowledge and skill, while diversifying and deepening certain intellectual and applied fields. This prepares

them for continuing their current studies and for a productive scientific life. (Ministry of Education, 2010: 4)

3 THEORETICAL FRAMEWORK AND PREVIOUS STUDIES

The establishment and emergence of network thinking is largely attributed to Frederick Pfister, through his bio-cyber approach, which he consistently pursued for years. He demonstrated a method by which we can create sustainable living conditions for humanity through network thinking. Pfister calls network thinking an "art," using numerous examples to illustrate the limits of understanding complexity—or rather, understanding reality intuitively and artistically. He explains how each of us can creatively utilize and shape complexity within our respective spheres of responsibility to ensure the future of humanity. (Fester, 1999:8)

Network thinking activates flexible connections between diverse ideas, rather than relying solely on logical and sequential relationships. It allows the mind to be open to establishing unprecedented links between information from different fields, thus generating creativity and innovation. Network thinking operates on two levels: individual, where it unleashes creative potential suppressed by traditional upbringing, and collective, where it creates a space for people to develop innovative ideas through creative collaboration and intellectual synergy. (Abadi, 2014: 11) Furthermore, there are numerous cognitive errors and practices that individuals fall into when faced with complex problems. According to Stroschneider (2002), one of the most significant errors lies in reasoning, and these include:

- 1 Dominance of experience
- 2 Inaccuracy in situation analysis
- 3 Unclear goals
- 4 Ignoring side effects/long-term consequences
- 5 Linear if-then thinking
- 6 Low self-reflection (Braun, 2002)

Therefore, there are steps for network thinking when dealing with complex problems, which are:

The network thinking methodology includes six basic steps that depend on and are interconnected with each other:

1-Defining the objectives and modeling the problem situation

It is important and necessary to define the problem precisely from the beginning in order to think in networks and understand the possible causal relationships.

2-Analysis of the Path of Effects:

In the second step, the relationships within the complex situation are analyzed. Networking techniques allow for mapping the connections, time periods, trends, and intensity of the relationship.

3-Identifying and interpreting change possibilities:

Identifying and interpreting change possibilities requires uncovering developments within the network. Since these processes are dynamic and systems are subject to change, it is advisable to isolate individual cycles and test them individually. This allows for the development of primary and alternative scenarios, which can then be used to evaluate various change possibilities.

4-Clarifying orientation options:

Based on the previous step, network thinking distinguishes between controllable and uncontrollable variables and indicators.

5-Planning Strategies and Measures:

In step five, strategies and alternatives are developed to determine how to address the problem and its components.

6-Implementing the Problem Solution:

After identifying suitable alternatives in the previous step, the next step is to choose among the possible options and implement the strategies. It is important to remember that solving a problem may trigger new processes. Therefore, solutions should be reviewed and adapted to the changing situation as needed. Thus, network thinking represents a sequential and interconnected process. (Martin, 2009: 2)

3.1 Network thinking skills

1- Network Classification Skill: This refers to the systematic sorting of objects into groups or categories that share a common characteristic.

2- Network Analysis Skill: This refers to the systematic breakdown of given educational material, recognizing similarities, differences, and relationships between parts, and identifying the principles governing these relationships.
3- Network Synthesis Skill: This refers to the systematic assembly of different parts of content, a main theme, or ideas to create something new that differs from previous parts.
4- Network Relationship Perception Skill: This refers to recognizing relationships within a single topic, idea, or paragraph. (Al-Naeem & Al-Ballah, 2023: 59)

3.2 Cognitive complexity theory explains network thinking

This theory has been used since the 1960s in the fields of cognitive psychology and educational psychology. William G. Kelly laid the theoretical foundation for this theory through his theory of individual cognitive structures, emphasizing that individuals construct "cognitive structures" to interpret the world, and that these structures vary in complexity. James Bieri (1955) further developed the concept to make it more measurable by measuring an individual's cognitive complexity and linking it to their ability to solve problems and make decisions in different social and cognitive situations.

The concept of "cognitive complexity" explicitly refers to the developmental aspects of an individual's cognitive structure. The general idea is that as an individual's structure develops, it becomes more differentiated (O'Keefe, 1981: 72-73). This theory describes the components of network thinking according to Markel (2012), showing the possibility of describing the problems students face through three components of network thinking: the interaction between differentiation, differentiation, and integration

3.2.1 Differentiation

This refers to the number of structures in an individual's cognitive structure and the developmental aspects of that structure. The general idea is that as an individual's cognitive structure develops, it becomes more differentiated. (O'Keefe, 1981: 72-73)

3.2.2 Differentiation

Individuals are differentiated according to their structural characteristics, that is, according to their attitudes, ways of thinking, and motivations. This analysis and differentiation are carried out based on the dimensions of differentiation, followed by differentiation and integration. Seiler (1986) describes differentiation as the number of differentiation categories available to an individual's cognitive evaluation system. A similar formulation describes differentiation as the number of main categories or dimensions that an individual can rely on when perceiving environmental stimuli, since differentiation is a measure of precise differentiation within a category

3.2.3 Integration

This involves organizing categories, motivations, and rules. It includes the ability to connect and coordinate multiple aspects of categories, as well as forming evaluative perspectives and finding alternative ways of acting. Schroeder and Swedfeld (1971) describe integrativeness as the ability to compare or balance alternative solutions and judgments, and the ability to respond creatively to complex questions or problems. (Merkel, 2012: 30)

3.3 Previous studies

1- (Kaderli, Franziska, 2007)

The effectiveness of an educational intervention in developing network thinking among primary school students within the framework of education for sustainable development

This study aimed to determine the effectiveness of an educational intervention based on the principles of Education for Sustainable Development in developing network thinking skills among primary school students. The study sample consisted of 282 male and female students from the first and second grades of primary school, who were divided into experimental groups that underwent an educational intervention program, and control groups that did not receive any educational intervention. The study adopted a quasi-

experimental design and used tools that included educational tasks, analysis of student responses, and structured observation to measure the components of network thinking. After conducting statistical analysis using one-way ANOVA and post-hoc comparison tests,The results showed statistically significant differences in favor of the experimental groups in the post-test measurement, which may indicate the effectiveness of the educational intervention in developing network thinking among primary school students)Kaderli, Franziska, 2007(

2- Mansur (2020)-2

The Impact of Using Network Thinking on Developing Cognitive Achievement in Some International Basketball Law Materials

This research aimed to identify the impact of using network thinking on developing cognitive achievement in some international basketball law materials for third-year female students at the Faculty of Physical Education for Girls, Alexandria University. The researcher used the experimental method, and the research tools consisted of a cognitive test and an intelligence scale, which were applied to a random sample of (93) female students from the third year, Education Department.

The research results confirmed that the use of network thinking has a positive impact on the level of cognitive achievement in some subjects of international basketball law for third-year female students in the education department. The research recommended the necessity of using the network thinking method in teaching the theoretical content of the basketball course due to its positive impact on the level of cognitive achievement, and conducting similar research that addresses other aspects of the basketball course. (Mansour, 2020)

3- Suwaidan (2023)

(An educational program based on network thinking and its impact on the cognitive achievement of some international law materials in karate)

This research aimed to identify the impact of a network-based learning program on the cognitive achievement of certain international law topics in karate. The sample consisted of 92 female students, divided as follows: 46 students in the experimental group, who received network-based learning, and 46 students in the control group, who received traditional instruction. The following statistical methods were used, as they are

appropriate to the nature of the research: the arithmetic mean, standard deviation, Pearson correlation coefficient, and the Mann-Whitney U test for statistical significance.

The differences between two independent groups and the significance test of the differences between two independent groups led to the following results: There are statistically significant differences between the pre- and post-tests in the level of cognitive achievement in some international law articles in karate for the control group, in favor of the post-test. (Suwaidan, 2023)

4 APPROACH OF RESEARCH&PROCEDURES

The current research adopted the descriptive analytical approach to achieve the research objectives.

4.1 The population of research

The research population refers to the entire group with observable and measurable common elements and characteristics to which the research seeks to generalize findings related to the problem. Defining the research population is a crucial step in experimental research and requires extreme precision, as the research procedures, design, and the validity of its results depend upon it (Shafiq, 2001: 18). The current research population consists of all preparatory and secondary schools for boys and girls.

The Kirkuk Governorate Education Directorate, specifically the Kirkuk City Center branch, oversees 149 schools for the 2025-2026 academic year. This includes 84 secondary schools and 65 preparatory schools, according to statistics from the Kirkuk Education Directorate's Planning Department for the same academic year. This current research focuses solely on fifth-grade preparatory students in the preparatory and secondary schools within Kirkuk City Center for the 2025-2026 academic year, totaling 16,953 in the science track and 3,466 in the humanities track.

4.2 Second: research samples

Selecting a research sample is one of the most important steps in research, as the researcher may find it difficult to conduct the study and collect data that includes all members of the research population. Therefore, they resort to selecting a representative sample of the population to use in collecting data and generalizing results. (Abu Huwaij, 2002: 45). Accordingly, the researchers determined the research samples according to the following procedures:

1- A list of schools representing the original research population was compiled.

2 - For the statistical analysis of the network thinking scale, the researchers used several samples for the current study, as shown in Table(1) sample statistical analysis:

Table 1

Types of research sample

No	Samples used	Number of students
1	Statistical analysis sample	300
2	Reliability sampling (test-retest method)	50
3	Sample application	100

The statistical analysis sample for the network thinking scale consisted of (300) male and female students who were randomly selected from the research population, and Table (2) shows this

Table 2

Statistical analysis sample

No.	the school	number
1	Al Wathba Secondary School for Boys	20
2	Martyr Ismail Ibrahim Preparatory School for Boys	26
3	Barlak Boys' High School	22

4	Al-Sadr Preparatory School for Boys	28
5	Martyr Nazhan Al-Jubouri Preparatory School for Boys	29
6	Al-Mustaqbal Preparatory School for Boys	24
7	Integrity High School for Girls	26
8	Nour Iraq High School for Girls	28
9	April 9th Girls' School	21
10	Al-Khansaa Preparatory School for Girls	30
11	Al-Huda Preparatory School for Girls	26
12	Al-Baydaa Preparatory School for Girls	20
the total		300

4.3 Third: the search tool: network thinking scale

In order to measure the research variable (network thinking) among fifth-grade preparatory students, it was necessary to build a scale for it. The two researchers, by referring to the theoretical literature on the study of network thinking, relied on the theory of cognitive complexity in determining the components of network thinking, and based on the study of (Markle 2012), a set of scale items was formulated in its initial form, which consisted of (33) items according to situations for three graded alternatives, and they were distributed over the scale's (three) domains, with (11) items for each domain.

In light of this, the areas of the scale were defined as follows:

4.3.1 A. Initial description of the scale:

The network thinking scale consists of (33) items and the scale has three situations

Table 3

The number of items for the Network Thinking Scale is shown, distributed according to domains

Scale	Domains	Number of paragraphs	Paragraph numbers
Network thinking	Differentiation	11	1،2،3،4،5،6،7،8،9،10،11
	Differentiation	11	12،13،14،15،16،17،18،19،20،21،22
	integration	11	23،24،25،26،27،28،29،30،31،32،33
the total	3	33	

4.3.2 B. Psychometric properties of the scale (face validity)

To ensure the validity of the scale items, they were presented to a group of experts and referees in the field of educational and psychological sciences, numbering (15), to express their opinion on the validity of the items and their belonging to the field for which they were created, the clarity of the items and the soundness of the linguistic formulation, and any observations and modifications they deem appropriate. By comparing the values of (Chi2) calculated with the tabulated value of (3.84) at a significance level of (0.05) and a degree of freedom of (1), it was found that all items were accepted as shown in Table No. (4).

Table 4

The chi-square value of expert and referee opinions on the validity of the paragraphs

Domains	Paragraph number	Valid	Invalid	Chi-square value		Significance level(0.05)
				Calculated	Tabulation	
Differentiation	،5 ،4 ،3 ،2 ،1 ،10 ،9 ،7 ،6 13 ،12 ،11	15	0	15	3.84	statistically significant
	8	14	1	11.260		
Differentiation	،4 ،3 ، 2 ،1 ،9 ،8 ،7 ،6 ،5 ،11،12 ،10 13	15	0	15		
integration	،4 ، 3 ، 2 ،1 ،9 ،8 ،7 ،6 ،5 12،	15	0	15		
	13 ،11 ،10	13	2	8.066		

4.3.3 C: The discriminatory power of the paragraphs

The items of the Network Thinking Scale were analyzed in a statistical analysis sample of (300) fifth-grade preparatory students using:

4.3.3.1 The extreme groups method (item discrimination power)

Item discrimination power is one of the important psychometric properties that can be relied upon to evaluate the efficiency of the item in measuring the trait to be measured because it distinguishes

1. Between individuals who score highly on the measured trait and those who score low (Mansour, 2007: 238), the researchers followed these procedures to achieve this:
2. Applying the network thinking scale to a sample of (300) male and female students as shown in Table (2).
3. The forms were corrected and the total score for each form was determined.
4. Arrange the forms in descending order.
5. Appoint 27% of the forms with the highest scores, and 27% of the forms with the lowest scores.
6. He specified (81) forms for the upper group and (81) forms for the lower group, and thus the number of forms reached (162) forms.
7. The arithmetic mean and standard deviation were extracted for each item in the upper group, and corresponding to the lower group, for all items of the scale.
8. The researchers used the t-test for two independent samples to test the differences between the item scores of the upper and lower groups, and compared them with the tabulated t-value (1.972) at a degree of freedom of (160) and at a level of (0.05). All items were considered distinctive, except for items (1), (7), (8), and (27), where it was found that the calculated value was less than the tabulated value, as shown in Table (5)

Table 5

Discriminatory power of items on the Network Thinking Scale

Paragraphs	Senior group		Minimum group		T value		Significance level at 0.05
	Arithmetic average	Standard deviation	Arithmetic average	Standard deviation	Calculated	Tabulation	
1	**2.78**	**1.012**	**2.54**	**0.988**	**1.492**		**Non-functional**
2	3.05	0.960	2.30	1.066	4.724		Function
3	3.35	0.744	2.30	1.089	7.160		Function
4	3.07	1.046	2.02	1.037	6.413		Function
5	3.10	0.970	2.19	1.074	5.683		Function
6	2.98	0.961	1.86	0.932	7.468		Function
7	**2.83**	**1.022**	**2.57**	**1.172**	**1.500**		**Non-functional**
8	**2.85**	**1.050**	**2.59**	**1.093**	**1.539**		**Non-functional**
9	3.41	0.891	2.17	1.082	7.928		Function
10	2.96	1.054	2.09	1.075	5.241		Function
11	3.01	1.055	1.85	0.976	7.268		Function
12	3.00	1.072	2.04	1.078	5.701		Function
13	3.06	1.076	2.21	1.069	5.054		Function
14	3.04	1.030	1.99	0.955	6.723		Function
15	3.10	0.875	2.00	1.000	7.443		Function
16	3.07	1.081	1.96	1.112	6.448		Function
17	2.99	1.066	2.02	1.095	5.670	1.972	Function
18	2.95	0.999	2.11	1.072	5.156		Function
19	3.09	1.027	1.84	0.843	8.444		Function
20	3.11	1.000	1.93	1.010	7.506		Function
21	3.21	0.971	2.37	1.167	4.978		Function
22	3.16	1.054	2.17	1.010	6.089		Function
23	3.06	0.927	2.01	1.031	6.814		Function
24	3.20	0.980	2.11	1.012	6.939		Function
25	3.14	0.959	2.05	1.059	6.844		Function
26	3.11	0.987	2.11	1.072	6.174		Function
27	**2.75**	**1.113**	**2.52**	**1.014**	**1.402**		**Non-functional**
28	2.72	1.121	1.93	0.985	4.767		Function
29	2.59	1.127	1.79	0.958	4.883		Function
30	3.10	0.957	2.05	1.128	6.385		Function
31	3.00	0.987	1.96	1.054	6.462		Function
32	2.90	1.032	1.98	1.024	5.731		Function
33	2.95	1.036	2.02	1.024	5.721		Function

4.3.3.2 The relationship of the item to the total score on the scale-2

Pearson's correlation coefficient was used to extract the correlation between each of the scale items and the total score of the scale. After obtaining the results and comparing them with the correlation coefficients calculated with the tabulated value of the correlation coefficient of (0.112), the results showed that all items were statistically significant at the level of (0.05), and all items of the Network Thinking Scale were accepted. Table (6) illustrates this

Table 6

Correlation coefficients between item score and total scale score

Paragraph	Correlation coefficient	Paragraph	Correlation coefficient	Paragraph	Correlation coefficient
1	She fell	**12**	0.386	**23**	0.401
2	0.326	**13**	0.411	**24**	0.461
3	0.402	**14**	0.418	**25**	0.441
4	0.466	**15**	0.414	**26**	0.369
5	0.377	**16**	0.414	**27**	She fell
6	0.435	**17**	0.409	**28**	0.389
7	She fell	**18**	0.388	**29**	0.291
8	She fell	**19**	0.399	**30**	0.377
9	0.434	**20**	0.380	**31**	0.380
10	0.360	**21**	0.347	**32**	0.374
11	0.436	**22**	0.411	**33**	0.317

4.3.3.3 Calculate the relationship between the item score and the score of the domain to which it belongs

Pearson's correlation coefficient was calculated between the score of each item and the score of the domain to which it belongs. It was found that all correlation coefficients were greater than the tabulated value at the level of (0.05) and amounted to (0.112), and all of them were statistically significant, which indicates the validity of its construction and its suitability for measuring network thinking. Table (7) illustrates this.

Table 7

The relationship of the paragraph score to the field to which it belongs

The first area Discrimination		**The second area Discrimination**		**The third area integration**	
Paragraph	**Correlation coefficient**	**Paragraph**	**Correlation coefficient**	**Paragraph**	**Correlation coefficient**
1	She fell	**12**	0.464	**23**	0.408
2	0.397	**13**	0.444	**24**	0.501
3	0.482	**14**	0.466	**25**	0.501
4	0.550	**15**	0.441	**26**	0.442
5	0.436	**16**	0.475	**27**	She fell
6	0.494	**17**	0.449	**28**	0.410
7	She fell	**18**	0.413	**29**	0.376
8	She fell	**19**	0.429	**30**	0.448
9	0.535	**20**	0.493	**31**	0.480
10	0.468	**21**	0.420	**32**	0.476
11	0.545	**22**	0.463	**33**	0.419

4.3.3.4 The relationship between the domain score and the overall scale score

To verify this, Pearson's correlation coefficient was calculated for the total score of the scale and the total score of the domain. It was found that all correlation coefficients were statistically significant when comparing the calculated values with the tabulated value of the correlation coefficient of (0.112) at a significance level of (0.05). Table (8) illustrates this.

Table 8

Relationship between the domain score and the overall scale score

Domains	Correlation coefficient
The first field	0.827
The second field	0.882
The third field	0.852

4.3.3.5 The relationship of the domain score to other domains (correlation matrix)

To verify this, Pearson's correlation coefficient was calculated for each domain and the other domains of the scale. It was found that all correlation coefficients were statistically significant when comparing the calculated values with the tabulated value of the correlation coefficient of (0.112) at a significance level of (0.05). Table (9) illustrates this.

Table 9

Correlation between the score of one domain and the other domain of the scale (correlation matrix)

domain	Excellence	Excellence	integration
Excellence	1	0.606	0.569
Excellence		1	0.610
integration			1

4.4 Second: stability

The researchers determined the reliability of the scale using two methods

4.4.1 Test and retest method

According to this method, the reliability coefficient refers to the degree of correlation between the scores obtained by the examinee when the test was administered the first time and their scores when the test was administered the second time. The correlation coefficient obtained is considered an indicator of the test's reliability (Jawdah, 2009: 198)

To calculate the reliability of the Network Thinking Scale using the test-retest method, the scale was administered to a sample of (50) fifth-grade preparatory students. It was then re-administered to the same group after (15) days. The relationship between the scores of the first and second administrations was then calculated using Pearson's correlation coefficient. The reliability coefficient was (0.85), which is a good indicator of the consistency of the students' responses on the Network Thinking Scale, confirming that the scale enjoys high reliability. Allen and Yen stated that if a test achieves a reliability rate of 80%, it is considered high reliability, which is a good reliability coefficient. (Allen and Yen, 1979: 95)

4.4.2 Cronbach's alpha method-2

In order to extract the reliability of the current scale using Cronbach's alpha, (100) male and female students were included in the statistical analysis sample using the random method. The value of the reliability coefficient was (0.81), which is a good reliability coefficient. Therefore, it can be said that the current research has succeeded in building a tool to measure network thinking that has indicators of validity and reliability, as well as an indicator of the analysis of items and their efficiency to distinguish between the respondents, as shown in Table (10).

Table 10

Reliability coefficients for the Network Thinking Scale

NO.	Method type	Stability coefficient
1	Test and retest	0.85
2	Cronbach's alpha	0.81

4.5 Statistical methods

The researchers used the Statistical Package for the Social Sciences (SPSS) as follows:1

1- T-test for two independent samples: Used to determine the discrimination of items on the Network Thinking Scale.

2- Pearson correlation coefficient: Used to determine the correlation between an item and the total score, the correlation between an item and a domain, the correlation between domains, and the reliability of the scale.

3-Cronbach's alpha equation: Used to determine the internal consistency and reliability of the Network Thinking Scale.

4- Chi-square test: Used to determine the percentage of expert agreement on the Network Thinking Scale.

5 SHOW RESULTS

The first objective was to identify the level of network thinking among fifth-grade preparatory students.

This objective was achieved by administering the network thinking scale to the sample. Statistical analysis of the results showed that the mean score for the sample was 58.65, with a standard deviation of 9.101. When compared to the hypothetical mean of 72.5, the mean score was found to be lower than the hypothetical mean of the network thinking scale. To verify the significance of the difference between the arithmetic mean of the scores of the sample members and the hypothetical mean, the two researchers resorted to using a t-test for a single sample. The calculated t-value reached (15,217) degrees. When compared to the tabulated t-value of (1,984) at a significance level of (0.05) and degrees of freedom of (99), it became clear that the calculated t-value is greater than the tabulated value. This means that there are statistically significant differences between the two arithmetic means in favor of the hypothetical mean. Table (11) illustrates this.

Table 11

Results of a single-sample t-test on the Network Thinking Scale

number	Arithmetic average	Standard deviation	Degree of freedom	Hypothetical mean	T value		Significance at 0.05
					Calculated	Tabulation	
100	58,65	9,101	99	72,5	15,217	1,984	غير دالة

The above results indicate that fifth-grade preparatory students have a weakness in their network thinking skills.

The second objective was to determine the significance of the difference in network thinking skills among fifth-grade preparatory students according to the gender variable (male-female).

To determine the statistically significant differences in network thinking skills based on gender, the results showed that the mean score for males was (58.42), with a standard deviation of (9.446), while the mean score for females was (58.88), with a standard deviation of (8.833). When calculating the t-value for two independent samples to determine the significance of the differences, the calculated t-value was found to be (0.252), which is less than the critical t-value of (1.984) at a significance level of (0.05) and degrees of freedom of (98). This indicates that there are no statistically significant differences in network thinking skills.

The gender variable (male and female), and Table (12) illustrates this.

Table 12

Results of the independent samples t-test in network thinking according to the gender variable (male-female)

Sex	number	Arithmetic average	Standard deviation	T value		Degree of freedom	Significance level 0.05
				Calculated	Tabulation		
Males	50	58,42	9,446	0,252	1,984	98	Non-functional
Female	50	58,88	8,833				

The third objective was to determine the significance of the difference in network thinking skills among fifth-grade preparatory students according to their specialization (scientific vs. literary)

To determine if there were statistically significant differences in network thinking skills based on specialization, the results showed that the mean score for the scientific

stream was 59.58, with a standard deviation of 9.355, while the mean score for the literary stream was 57.72, with a standard deviation of 8.836. Calculating the t-value for two independent samples to determine the significance of the differences revealed a calculated t-value of 1.022, which is lower than the critical t-value of 1.984 at a significance level of 0.05 and 98 degrees of freedom. This indicates that there were no statistically significant differences in the specialization variable (scientific vs. literary). Table 13 illustrates this.

Table 13

Results of the independent samples t-test in network thinking according to the specialization variable (scientific – literary)

Specialization	number	Arithmetic average	Standard deviation	T value		Degree of freedom	Significance level 0.05
				Calculated	Tabulation		
scientific	50	59,58	9,355	1,022	1,984	98	Non-functional
literary	50	57,72	8,836				

6 RECOMMENDATIONS

In light of the research findings, the following recommendations were made:

1- The Ministry of Education should prioritize offering intensive training courses for educators in schools, familiarizing them with successful educational programs to enhance network thinking skills in the learning process.

2- Continued research and experimental studies should be conducted to develop and improve the educational process.

3- The Ministry of Education should utilize the network thinking assessment developed by the researchers to identify students with weaknesses in network thinking skills.

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1- The Ministry of Education should prioritize offering intensive training courses for educators in schools, familiarizing them with successful educational programs to enhance network thinking skills in the learning process.

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3- The Ministry of Education should utilize the network thinking assessment developed by the researchers to identify students with weaknesses in network thinking skills.

Recommendations

The researchers suggested the following future studies to further develop the research they will conduct:

1- Conduct a study to determine the nature of the relationship between network thinking and other variables such as analytical thinking, systems thinking, and cognitive complexity.

2- Conduct a similar study to investigate the effectiveness of educational programs in developing network thinking among a sample of middle school students.

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