

# Impact of a Teaching Strategy According to Nardo's Developed Model of Algebraic Thinking in Middle School Students

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## Abstract

*The objective of the research is to know the impact of a teaching strategy according to the Nardo's developed model of algebraic thinking among middle second graders and to achieve the research objective the two researchers selected divisions of (a, b) From (Mediterranean Zayn al-Abidin -A - Boys) of Baghdad/Karakb Education Directorate II for the academic year (2023-2024) The Division (a) represents the control group and includes (31) students who have studied in the usual manner, and a Division (b) The pilot group included (33) students studied according to the teaching strategy according to the Nardo developer model, and the two groups were rewarded (Control and experimental) in variables (pre-year attainment (2022-2023), previous knowledge in mathematics, intelligence) The researchers built the research tool with a algebraic thinking test in mathematics and included (33) Objective paragraph (multiple choice), verified its honesty and consistency as well as Cychometric properties. Results analysed using statistical means. After the duration of the trial, the test tool applied to the two groups (Experimental and control) The results showed that the students of the experimental group outperformed the students of the control group in the algebraic thinking test.*

**Keywords:** Teaching Strategy, Nardo's Developer Model, Forced Thinking, Middle Second Graders

## INTRODUCTION

### Search Problem

Mathematics is an abstract science that is characteristic of this science, it needs to develop multiple thinking patterns and mental abilities that can translate those abstract symbols. Since the reparation branch is an important branch of this article, as it is one of its basic components, Through which students learn many skills of ability to infer and extrapolate and the transformation of words into symbols, data analysis and information organization, and played an important role as an essential branch in the curriculum of mathematics at various levels of study, especially the curriculum of the middle level as it is the basis for the acquisition of the concepts and skills underpinning other stages' curricula, Through this, the need for genuine and serious attention has arisen in this section of mathematics. In their teaching experience, researchers have found a marked weakness in algebraic thinking among middle second graders. And this indicates that there is a real problem that the educational institution seeks to find solutions to, It also affects the learning of thinking skills in general, and this is confirmed by many mathematics teachers and supervisors.

One of the reasons for their difficulty in learning may be the teaching of their concepts and skills in traditional methods of preservation and indoctrination, and to confirm the problem of research the two researchers provided an exploratory questionnaire for mathematics teachers.

The problem of searching is determined by the answer to the following question:

What is the impact of a teaching strategy according to Nardo's developed model of algebraic thinking among middle second graders" ?

### The Importance of Research

Intermediate education is the stage of thinking and cognitive building. At this stage, the learner must be given an active role to train them in knowledge discovery and collection from its multiple sources. The teacher's role

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is to guide and guide. (El Tai, 2005) The pedagogical arena has therefore witnessed numerous models, strategies and various ways of building and acquiring knowledge. (Rikabi, 2024). These models and strategies are in line with today's scientific revolution in the field of technological techniques (El Fayyad, 2024). This cognitive development is a turning point in dealing with knowledge and ways of communicating it to facilitate man's adaptation to changes in his social and cultural environment. (Jawad) & et al, 2021), among these recent models is the developed Nardo model, which involves students using simulation method with computer programs and with audio-visual means, so that they developed the discovery phase with the Nardo model)) because they sought to keep up with modern techniques in the evidentiary construction of the learning process. (Zaire and Others, 2017), as an essential step, research came to help learners improve thinking and learning and develop their potential to solve the problems they face. (Hadi, 2018).

## **Research Objective**

Current research aims to identify the impact of a teaching strategy according to Nardo's developed model of algebraic thinking in middle second graders, Research hypothesis

In order to achieve the research's objective, the following hypothesis was formulated:

"There is no statistically significant difference at 0.05 between the average grades of the pilot group students to be studied according to a teaching strategy according to the Nardo developer model and the grades of the control group students to be studied in the usual way in the algebraic thinking test."

## **Search Limits**

- 1- Intermediate second grade students in the Government's intermediate and daytime schools of the General Directorate of Education of Baghdad/Karakh II for the academic year (2023 - 2024).
- 2- First semester for the academic year 2023 (-2024).
- 3- Mathematics Book scheduled by the Ministry of Education containing chapters (chap. II/Real Numbers, chap. III/Border, chap. IV/Equations and Discrepancies), p. 5, revised, 2023, for middle grade II.

## **Definition of Terminology**

### **NARDO Developer Model**

A- Zaire and Others, 2017, defines it as "a model developed from the learning course in the United States of America that involves students using simulations (similar) with computer programs and audio-visual means and tools. Those developing discovery seek to keep pace with modern techniques in the evidentiary construction of the learning process."

B- al naeeli , 2023, defines it as "the set of structured actions and steps that are (preliminary - posing the problem - self-thinking - facilitating understanding - exploring - organizing and rebuilding knowledge) that are planned in advance, aiming to change and stimulate the pattern of thinking using modern techniques with the aim of receiving and embodying information in front of students and resulting in the ability to retain information for longer".

The researchers adopted a theoretical definition of Zaire and Others, 2017.

The two researchers procedurally define it as a set of teaching steps taken by the two researchers to teach mathematics to middle-grade students with a view to improving their algebraic thinking.

### **Forced Thinking Algebraic**

The following are known:

(Dindyal, 2003): the ability to use all symbols and forced relationships, to use multiple representation, and also to use mathematical patterns and generalizations.

(Windsor, 2010) It is one of the most important patterns of mathematical reasoning and reasoning that is associated with mental processes undertaken by students to accommodate and describe mathematical patterns and relationships, and to reach new mathematical relationships and conclusions about preparation and processes.

The researchers adopted the definition (Windsor, 2010) as a theoretical definition of its suitability for current research.

The two researchers know it procedurally: one of the patterns of mathematical thinking or reasoning that is associated with the mental processes carried out by middle second graders to assimilate and describe mathematical patterns and relationships, and to conclude new mathematical relationships about the preparation and processes thereof, and can be measured by the overall degree to which middle second graders will receive the test of algebraic thinking prepared by the researcher on the specific skills of forced thinking. (Use of symbols and forced relationships - use of sports representation - use of patterns and generalizations - logical reasoning to address and solve problems).

## **Chapter II: Review of the Reper**

### **First Axis: Theoretical Framework**

The theoretical framework is a fundamental necessity of scientific research and its importance is that it represents the natural boundaries of each research, and one of the sober scientific foundations on which the researcher can draw in all the steps of his research from his choice of title through the identification of actions and their implementation, depending on his interpretation of the results of his research. ( 2020 Faris and others,)

Based on the foregoing, the two researchers have addressed constructive theory through the literature on which it is based, and their ideas can be applied and relied upon in scientific research.

Constructive Theory

### **Concept of Constructive Theory**

Constructive theory is an educational philosophy in which a learner builds his or her own knowledge, based on his or her current knowledge and past experience. This theory emphasizes the effective role of a learner in the presence of a mentor, facilitator and assistance in building meaning in a way that helps to optimize learning. (2022 Risen and others,) and the constructive philosophy aims to help learners store knowledge and its fundamentals in memory so that it is a sound scientific pillar for them, By understanding this knowledge and using it to solve the problems they face in life situations To be able to use them to understand all the phenomena surrounding them, they gather information, discuss those problems and find appropriate solutions to them. and to discuss these solutions with colleagues, and then the possibility of their scientific application. (Abu Rayash, 2007) Because the theory assumes that it is the learner who builds his knowledge while experiencing problems that he tries to understand and interpret, because he is a living object looking for knowledge permanently. (Abdul Karim, 2011).

### **NARDO Developer Model**

The model was developed by English professor Teresa Pengas Nardo, Dean of the Faculty of Literature and Science at Merco Buana University in Jakarta, Indonesia (2019), and applied this model in 2012 at the institution where she works, working at several international universities. (Al-Na 'li, 2023)

Nardo developed this model of learning courses in the United States and was tested at the Captol School in 2000, which includes the use of simulations, computer software, audio-visual tools and tools, and its importance is summarized by the development of the discovery phase in the model (Nardo) In order to keep abreast of modern developments and techniques in the evidentiary construction of the learning process, the developers of this model looked at the foundations of the educational problem, where students learn how to solve the problem presented to them themselves, rather than receiving the instructions ready on how to solve, and the role of the teacher is a guide, (Zaire, 2017)

## **NARDO Developer Model Stages**

### **First: Simulation**

It is a Latin term defined in the lexicon of pedagogical techniques as an alternative system used in the teaching of activities, so that the situation is closer to the normal situation in which operations are performed, and the simulation word indicates similar and similar in the act or the saying. (Saliba, 1994)

It is defined as sensory, motivational, focused and accurate observation practices consisting of visual, acoustic and motor effect elements that increase learners' motivation. A model of a realistic world in which students play different roles, such as problem analysis and decision-making, is one of the learning methods that depends on students' activities so as to link theory and practice in realistic situations that facilitate understanding of scientific material so that it is delivered to students in interesting ways. (Ambo Saidi and Baluchi, 2009)

### **Second: Computer Usage**

The computer is a means of communication that provides better educational services to learners, increases their experience, addresses their shortcomings in training or experiences, reduces the use of tutoring in the future, and that its uses in learning and education processes are many, and these programs allow the learner to interact with content. (Amer, 2014)

### **Third: Presentation Programmes**

The PowerPoint program is used as an educational tool by displaying slides with pre-prepared information. This type has several advantages that make it a successful educational means that students enjoy during the lesson. One of these features is the ease of use as an addition or deletion of slides and the ease of preservation and retrieval of the prepared slides. (Katit, 2015)

### **Fourth: Audiovisual Means**

Educational means are defined as "the tool provided by the teacher and ensures that it is usable and effective in its impact on learners and facilitates the classroom learning process". (Al Siliti, 2015), audio and visual means are also known as materials that are audio or visual and transmit information by audio and image, and include video, charts, still films, audio recordings and animated film slides. (Al-Shami, 1988)

## **NARDO Developer Model Steps**

Nardo's model consists of several steps:

### **First: Preface**

The teacher creates appropriate conditions such as identifying means, supplies and devices before starting to speak, and then presents a complete picture of the subject matter of the lesson you will take in his study.

### **Second: Posing the Problem**

In this step, the teacher presents the subject of the lesson in a problematic manner or several problems that raise the questions of learners and motivate them to research various ideas and then install them in their books in questions.

### **Third: Self-Reflection**

This stage consists of the learner being active, discussing and interlocutor, giving a number of ideas to solve the problem, with careful follow-up by the teacher to those ideas and their applicability.

IV. Facilitation of understanding:

A teacher here gives solutions close to the solution that solves the problem, making it easier for students to build meaning for their learning, and the more realistic and close to the learner's environment the better.

#### V. Exploration:

In this step, the information provided and the information stored within it are reorganized to search for new relationships between previous and new knowledge, and the student processes it, collects it and converts it into new information, and proves solutions with emphasis on the points of convergence. (Al Yasri and Others, 2013)

#### Sixth: Organization and reconstruction of knowledge:

Here the information and the rule are arranged according to the supplies and devices available.

(Zaire et al., 2017)

The two researchers proposed a teaching strategy in accordance with Nardo's developed model, in line with the educational environment of the target group in the research, and since the modern theories and entrances in the educational process are centred on the role of the student, the following steps have been taken:

First: The steps of self-reflection and exploration were combined with the third step), giving students a number of different solutions to the questions presented, with careful follow-up by the teacher to those solutions and the validity of their application. A working paper is distributed through questions. Students discover solutions and concepts and link their previous knowledge to new knowledge.

Second: Life applications have been added as the sixth step in the teaching strategy. In this step, lesson ideas are used to address the problems surrounding the student, i.e. the application of solutions, concepts and skills in life situations.

Third: The step of evaluation has been added and is intended to determine the student's ability to judge what has been learned and the extent to which he has achieved the goals set, to know the appropriateness of the methods used in the study, and to assess the effectiveness of the plan developed and its implementation.

The proposed teaching strategy consists of seven sequential steps, beginning with the preparation of the problem, self-reflection and exploration, facilitating understanding, organizing and rebuilding knowledge, and life applications, and ending in evaluation.

### **Forced Thinking**

Herbert & Brown, 1997; s view is that the use of mathematical symbols and instruments is to analyze different mathematical situations, by: reading and inferring information from mathematical attitudes, using shapes, symbols, tables and drawings, equations, representing mathematical information in the form of words, interpreting and applying mathematical results, such as solving issues to obtain values of variables. NCTM noted the school mathematics principles and standards document issued by the National Council of Mathematics Teachers (2000) That forced thinking addresses the understanding of patterns, functions, relationships, representation and analysis of forced structures, mathematical attitudes and understanding of quantitative relationships. The document emphasized the need to expect the pupil to think compulsory to support a smooth transition between calculation and reparation, as indicated in the document. (Dindyal, 2003 to the student's ability to use symbols, forced relationships, patterns and generalizations, multiple representation and clarification (Kieran, 2004) that there are five actions to achieve a successful transition from calculation to reparation is to focus on:

Relationships instead of counting only numerical answers.

Processes as well as reverse processes.

Solving and representing problems and not just solving them.

Numbers and symbols together rather than focusing on numbers alone.

The meaning of the equality mark.

Steele, 2005, considers algebraic thinking to be an individual's ability to analyze, represent and generalize relationships. He stated (Windsor, 2010) as one of the patterns of mathematical thinking or reasoning that is

associated with a learner's mental processes to accommodate mathematical relationships, describe patterns, and conclude a new mathematical relationship about preparation and processes.

### **Forced Thinking Skills**

(Dindyal, 2003) noted that forced thinking has three skills:

Use of forced relationships and symbols: the skill of using mathematical symbols and relationships extensively in rabbits for the expression of measurement units, ignorances and constants, and the translation of geometric forms.

Use of patterns and generalizations: patterns play an essential role in the development of algebraic thinking in students, and studies show the existence of many types of patterns such as: figurative pattern, geometric pattern, numerical pattern.

Use of multiple representations: skill intended to use tables and drawings to facilitate accurate and deep understanding of the substance's content.

### **Theme 2: Previous Studies**

Studies on Nardo's developer model:

Study (Al-Na 'ili, 2023): Conducted in Iraq and aimed at demonstrating the effectiveness of Nardo's developed model in the collection of history and the skill of evaluating arguments among fifth grade literary students.

Studies on algebraic thinking:

The studies dealing with the change of algebraic thinking are many and multiple. The two researchers selected the most relevant to the current research, which is consistent with the sample and type of curriculum and as follows:

A- Study (Roland pourdavood .et, al., 2020): Conducted in America, the study aimed at researching the quality of mental computational activity in the third grade and considered that the transition from computational thinking to algebraic thinking in early grades is essential in the study of patterns, numbers and numerical relationships.

B- Study (Abdullah, 2022): Conducted in Iraq and aimed at identifying the effectiveness of proposed strategies according to knowledge management models in the achievement of mathematics and forced thinking skills in middle school students.

### **Chapter 3: Research Methodology and Procedures**

The present chapter contains the methodological procedures followed by the two researchers to achieve the research objective as follows:

First: Research curriculum

The pilot curriculum was adopted to suit the nature of the research and to achieve its objectives.

Second: Experimental design

The two researchers adopted the experimental design of two independent equivalent groups (experimental and control) with dimensional test (dimensional test control group design and table (1) shows the experimental design of the research.

Table (1)

Tools	Dependent variable	Independent variable	Valences	Group
Algebraic	algebraic - thinking	Usual method	previous Attainment - mathematical - knowledge previous Intelligent -	Control
		A teaching strategy according to the developed nardo model		Experimental

### Third: The Research Community

The research community is represented by all students of the second middle grade in the Government's Secondary and Middle Day Schools affiliated to the General Directorate of Education in Baghdad/Karakh Governorate for the academic year (2023-2024).

### Fourth: Sample Research

The two researchers selected the second Baghdad/Karakh Education Directorate's Medium Zain al-Abidin for boys to be a sample for their research.

### Fifth: Control Procedures

Internal Safety of Experimental Design: To verify the internal safety of experimental design, the two researchers verified the parity of the research groups (experimental and control) with some variables, such as: Previous achievement in mathematics and previous knowledge in mathematics and intelligence, used in statistical data processing Levene's test for two independent samples, as shown in Table (2):

Table 2. Levene's test results for two separate samples for the research groups

Significance level	T test value	F value	Standard deviation	Arithmetic average	Number of students	Group	Variable
0.484	0.704	0.49	11.011	70.94	33	Experimental	Previous academic achievement in mathematics
			11.687	72.94	31	Control	
0.656	0.448	0.030	3.668	12.73	33	Experimental	Previous knowledge in mathematics
			3.553	12.32	31	Control	
0.796	0.260	0.219	7.968	22.39	33	Experimental	Intelligent
			8.131	21.87	31	Control	

External safety of experimental design: The two researchers sought to adjust other extraneous external variables that may affect the integrity of the external experimental design, as follows:

Duration: The trial was applied on Sunday (5/11/2023) and ended on Thursday (11/1/2024), and was uniform on both research groups.

Prescribed subjects: The subjects consisted of chapters (II, III and IV) of the math book scheduled for grade II, intermediate (2024-2023) m., series VIII, p. 5, revised.

Number and distribution of classes: The weekly course schedule for the second grade of mathematics is approved in turn by the school administration of five classes per week for each division.

### **Sixth: Preparing Research Requirements**

Suggestion of the steps of the teaching strategy: Three steps were proposed: (Integration of the steps of self-thinking and exploration - life applications - calendar). This proposal was also based on the Nardo developer model.

Content Analysis: After reading the subjects of the math book for the second middle grade, revised section 5, containing chapters (II: Real Numbers, III: Boundaries, IV: Equations and Discrepancies), the content of the material was analyzed according to the components of mathematical knowledge.

Formulation of behavioral purposes: behavioral purposes were formulated depending on Bloom's classification of the field of knowledge (remembrance, assimilation, application, analysis, composition, evaluation).

Preparation of teaching plans: Daily teaching plans have been prepared for the experimental and control groups in the light of pre-prepared behavioural purposes in the light of the analysis of the content of the subjects of the scientific material.

### **Seventh: Search Tool**

A tool was built to measure the subordinate research variable of the algebraic thinking test, to verify the objective and hypothesis of the research that contributes to solving its problem. The objective of the test was set, which aims to measure the algebraic thinking skills of the students in the second grade, and by familiarizing the researchers with several classifications adopted by the classification (Carpenter & Levi, 2000) because it is suitable for the sample of research, and these skills are (Use patterns and generalizations, sports representation skill, use of forced symbols and relationships, logical reasoning to address and solve problems).

The following was done to arrive at the final test and apply it to the research sample:

Certification of the test: The ability of the test to measure what it was designed for means. The test paragraphs were presented to a number of arbitrators and specialists in mathematics specialization and the methods of teaching mathematics to judge the relevance and relevance of its paragraphs to the sample of research and to make their observations and suggestions thereon.

Consistency: To verify the stability of the test, the two researchers applied an equation (Keyoder-Richardson20) to the test paragraphs. The results showed that the constant factor for the algebraic thinking test is (0.78).

Application of the test to the sample information: To ascertain the clarity of the test paragraphs and instructions and to determine the time taken in the answer, the test was applied to a sample of 30 students who are not the current research sample of the students of the second middle grade in (Medium Great Messenger of Boys) one of the second Baghdad/Karakh education schools.

Application of the test to the statistical analysis sample: The goal of the second exploratory application is statistical analysis of the test paragraphs and calculation of psychometric properties.

Final test of algebraic thinking: The final test is an objective-type paragraph (33).

**Eighth: Procedures for applying the experiment:** the following steps have been followed:

Parity procedures were applied to the two research groups before the trial began in each of the following:

IQ test on Wednesday (1/11/2023).

Test previous information on Thursday (2023/11/2).

The researchers began their experiment on Sunday (5/11/2023), with 5 classes per week, and ended on Thursday (11/1/2024), after completing the course to be taught in the experiment.

The students of the pilot group of Division (b) were taught according to the teaching strategy in accordance with the Nardo's developed model and in the light of the daily teaching plans prepared for the specialists, and the students of the control group of Division (a) were taught in the usual manner.



## Chapter 4: Presentation and Interpretation of Results

First: Presentation of results: Results related to zero hypothesis that stipulate the following:

"There is no statistically significant difference at 0.05 between the average grades of the pilot group students to be studied according to a teaching strategy according to the Nardo developer model and the grades of the control group students to be studied in the usual way in the algebraic thinking test." To verify the validity of the second zero hypothesis, the following were carried out:

After applying the algebraic thinking test and correcting students' answers and organizing them in a special table,

The Leven's Test test was applied for two equal independent samples to determine the difference between the students' grades of the experimental and control groups, with F (0.016) at an indicative level (0.90) greater than the approved indicator level (0.05), which means that the two groups are homogeneous in this variable and as shown in table (3).

Table (3) Average arithmetic, standard deviation, F value and indicative level

Indicator at 0.05	Indicator level	F value	Standard deviation	Arithmetic average	Number of students	Group
D statistically	0.90	0.016	11.67	83.24	33	Experimental
			11.12	60.19	31	Control

### Second: Interpretation of Results

The results showed that the students of the experimental group studied according to the teaching strategy according to the developed Nardo model outperformed the students of the control group studied in the usual way in the algebraic thinking test. This superiority may be due to:

The teaching strategy provided an interactive environment centred around making the learner the centrepiece of the educational process working papers have been presented on an ongoing basis, individually or collectively, as well as the use of the display screen and the presentation of topics planned as problems, which students explore using videos shown to them that allow them to interact with the teacher on an ongoing basis and students to interact with each other. This makes it easier to understand and use sports content as basics in their algebraic thinking, which contains several skills that help them solve forced sports problems.

### Third: Conclusions

The teaching strategy raised students' skills in testing algebraic thinking among the students of the experimental group, compared to the students of the control group who studied according to the usual method.

### Fourth: Recommendations

In light of the research results, the two researchers recommend:

Encourage mathematics teachers and teachers to use the teaching strategy in accordance with Nardo's developed model when teaching mathematics for the middle stage, to demonstrate its effectiveness in improving algebraic thinking skills in middle second grade students.

### Fifth: Proposals

In the light of the current research procedures, the two researchers propose several proposals, including a study according to the teaching strategy according to the Nardo model developed in other variables, such as strategic intelligence, liquid intelligence, mathematical sense, behavioral variables such as motivation towards mathematics.

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