

Effectiveness of Using Elaboration Theory in Teaching Mathematics to Develop Academic Achievement and Critical Thinking For Primary Students in Oman

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Abstract

The study aimed to formulate the content of mathematics curriculum at the level of primary school students according to the elaboration theory, and measure the effectiveness of this mathematics content to develop the academic achievement and critical thinking skills. The study sample comprised (119) students in the fifth grade from Almanahl School in Salalah city of Dhofar Governorate, and were randomly divided into two groups. The first group was the experimental group (60 Students) and the other one was the control group (59 Students). Data were collected via the tests of achievement and critical thinking for the sample in geometric and measurement unit. The study was carried out in 25 times during 5 weeks. Data were analyzed using means, standard deviations, and T test. The study concluded that there was a significant difference at (0.05) between the academic achievement of the experimental group and that of the control group in favor of the experimental group, and there was a significant difference at (0.05) between the critical thinking skills of the experimental group and those of the control group in favor of the experimental group. In light of the results, the study recommended preparing the content of mathematics curriculum at the basic stage of education in accordance with the elaboration theory, and improving the mathematics teachers' performance to develop critical thinking skills for their students.

Keywords: Teaching Strategy, Elaboration Theory, Critical Thinking Skills, Teaching Mathematics, Primary Stage.

1. Introduction:

Thinking occupies an important place in the academic work, as it is one of the key goals of education in different stages of the learning process. In this regard, all the world's countries have developed and adopted some procedures towards organizing and developing the curricula so that students may learn methods of thinking in the way that contributes to developing the creative minds that can face the local and global challenges in different walks of life. In addition, a big number of writings and applications in the field of education have taken great interest in thinking (Rushton, 2006).

Critical thinking is one of the most significant types of thinking which allows learners to distinguish between what is good and bad of the information and ideas they receive, and in that way lets them not accept any customs or traditions, whether inherited or imported, except after reconsidering and judging them as being consistent with the values, customs and traditions of their society (Lyutykh, 2009).

Critical thinking is reflective thinking that focuses on decision making for what individuals think or actually do.

Mathematics is one of the courses that helps most learners develop thinking in all its forms, especially critical thinking due to its special nature, as it helps learners enhance their mental capabilities and develop their ways of deductive reasoning for solving problems. Moreover, it allows them to make organized discoveries that help them understand the surrounding world and analyze and solve the problems they face (N.C.T.M., 2009).

The good organization of the mathematics curriculum helps teachers to use the teaching strategy that agrees with the organization and sequence of information in the school book. It also helps students to use academic skills and effective mental processes that contribute to acquiring information and correctly storing them, which consequently keeps the learning effects for a long period and thus develops the learners' thinking skills.

Reigeluth Elaboration Theory is one of the educational theories that is based on the cognitive school of psychology to organize the content of curricula in a way that helps to merge the new information with learners' previous information and experience, making them inseparable and thus leading to significant learning (Cakiroglu, 2014).

Elaboration Theory is based on three main principles: Learning starts from abstract ideas to concrete examples, organization of content moves from the general to the specific topics, and learning starts with a comprehensive and brief overview of the elements of the educational task. Then these elements are gradually elaborated and detailed, providing each phase of learning is linked to the previous or following phase (Kutlu, 2013).

1.1 Statement of the Problem:

The present study attempts to answer the following research questions:

1. What is the effectiveness of Elaboration Theory in the development of mathematical achievement for primary students in Dhofar Governorate?
2. What is the effectiveness of Elaboration Theory in the development of critical thinking skills for primary students in Dhofar Governorate?

1.2 Goals of the Study:

The study aims to formulate the content of mathematics curriculum at the level of primary school students according to the elaboration theory, and measure the effectiveness of this mathematics content to develop the academic achievement and critical thinking skills.

1.3.Hypotheses of the Study:

1. There is no significant difference at (0.05) between the academic achievement of the experimental group and that of the control group.
2. There is no significant difference at (0.05) between the critical thinking skills of the experimental group and those of the control group.

1.4.Limits of the Study:

The limits of the study were as follows:

1. Special schools in Dhofar Governorate.
2. The fifth grade students in Almanahl School in the city of Salalah.
3. The geometric and measurement unit of the content of mathematics curriculum for the fifth grade students.
4. The study was carried out during the academic year (2014/2015).

1.5 Terminology of the Study:

▪ Reigeluth Elaboration Theory:

It is an educational theory to organize the content of mathematics curriculum in the primary school through a chain of successive steps: The epitome, analogy, levels of elaboration, relating, summarizing, synthesizing, and expanded epitome.

▪ Academic Achievement:

It is an experience gained by the fifth grade students in Oman, as a result of the study of the geometric and measurement unit. This is measured by the grade students get in the achievement test specifically designed for this purpose.

▪ **Critical Thinking:**

It is a mental process which learners perform when they face a certain problem, through which they can practice a series of successive mental skills in a logical and organized way that enables them to judge and evaluate things related to the problem. In this way they can solve the problem and benefit from that in facing the future problems. This is measured by the grade students get in the critical thinking test specifically designed for this purpose.

2. Literature Review:

2.1. Reigeluth Elaboration Theory:

The 'Elaboration' concept belongs to the cognitive school of psychology. It is concerned with the thinking processes that occur in the minds of students with regard to the courses they learn, where concepts, principles, procedures and details are added to relate the old information that learners know with the new information they learn. This helps them to understand the new information and realize its relation with the previous information they have.

Reigeluth Theory is one of the new theories for designing and organizing the content elaborately, as it is based on progression from simple to complex and from general to specific issues in learning concepts, generalizations, skills and principles, including cognitive details as well as internal and external connections about the course (Tosone, et. al, 2008).

According to Reigeluth Theory, the course content is organized as follows (Kutlu, 2013), (Reigeluth, et. al, 1980):

- (A) **Epitome:** It includes the main and comprehensive ideas (concepts, principles, procedures, etc.) of the course content, in addition to illustrative examples for such ideas and sections for drills and practice. This epitome may be conceptual, procedural or theoretical.
- (B) **Analogy:** In this step the course content of the lesson in the expanded epitomes is compared to a topic familiar to learners and related to what was mentioned in the epitome, such as comparing (heart, pump), (mind, computer). This, in turn, helps to relate the new knowledge and information with the knowledge that is already there in the learners' cognitive structure.
- (C) **Levels of Elaboration:** It includes a gradual elaboration for what was mentioned in the expanded epitome (concepts, generalizations, principles, procedures, etc.) where the course content is gradually organized from the general to the specific (details) and from the simple to the complex and from the abstract to the concrete. The elaboration process may require one or more levels according to the volume of the course content and the learners' ability to grasp it.
- (D) **Relating:** In this step every elaborated phase is related to the previous or following phase, thus forming a comprehensive theory on the way the educational task and period are related to each other.
- (E) **Summarizing:** It includes a comprehensive summarization of the concepts, principles and procedures included in the course content, but without sections for drills and practice, feedback or counterexamples, as the case with the expanded epitome. This summarization is presented at the end of each main expanded level or at the end of each secondary expanded level.

(F) *Synthesizing*: In this step the relations that relate the elements of the course content to each other are illustrated in an integrated way so that learning could become significant for learners. This is accomplished through a diagram or a map illustrating the relations between elements.

(G) *Expanded Epitome*: It includes illustration of the relation that relates the elements of the course content of a certain topic to the elements of the course content of other topics.

2.2 Critical Thinking:

▪ Definition of Critical Thinking:

Having surveyed the definitions of critical thinking it was noticed that there are four approaches to definition of critical thinking:

(A) *The First Approach: Critical thinking as a skill to solve problems:*

This approach views critical thinking as that type of thinking in which individuals use their mental skills and strategies to specify the dimensions of the problems they face so as to evaluate them, making different conclusions, decisions and logical interpretations to solve such problems (Facione, 2011).

(B) *The Second Approach: Critical thinking and logical thinking are inseparable:*

This approach maintains that critical thinking is logical thinking based on inference and giving reflective judgments. Furthermore, it focuses on evaluating incidents, issuing judgments and giving justifications for what individuals believe or are absolutely sure of (Fisher, 2011).

(C) *The Third Approach: Critical thinking as an evaluative process:*

This approach contends that critical thinking is an evaluative process based on accuracy in examining the incidents related to a certain topic and deriving conclusions in a logical and objective way (Halpern, 1996).

(D) *The Fourth Approach: Critical thinking as an evaluative process and a skill to solve problems:*

This approach maintains that critical thinking is individuals' ability to judge, understand and evaluate things according to certain criteria through a number of skills such as: specifying assumptions, realizing relationship between data and what is required, making comparisons, evaluating rationality of results and making right decisions to solve the problems (Zoller & Mura, 2000). *The present study adopts this approach for it was commonly used in the last few years.*

▪ Critical Thinking Skills:

Though there are different opinions and viewpoints with regard to specifying the critical thinking skills, such skills can be specified as follows (Alosaimi, 2013):

(A) *Knowledge of assumptions and postulates*: These are the individuals' convictions about a given topic, where they can examine the incidents and data in such a topic in a way that they can judge that certain assumptions are likely or unlikely, according to the accurate examination of the given incidents.

- (B) **Interpretation:** It enables individuals to estimate evidence and distinguish between data and justified and unjustified instructions to reach the likely and justified conclusion. It is also represented in individuals' ability to reasonably draw a certain conclusion from assumed facts.
- (C) **Deriving:** It is individuals' judgment on whether a certain conclusion is drawn from certain premises. It is represented in individuals' ability to know and specify relations between certain incidents. In light of this knowledge they can determine whether a certain conclusion is derived from such premises, irrespective of the validity of these incidents.
- (D) **Deduction:** In this process the individuals reach a certain conclusion in light of given data and information is represented in their ability to specify whether a certain conclusion is right or wrong according to their relatedness to the incidents or data they are offered.
- (E) **Estimating arguments and discussions:** This means that individuals can distinguish between strong and weak arguments that are related to the topic. It is represented in individuals' ability to specify and realize the important aspects that are directly related to the topic, and distinguish between strong and weak aspects. These are the skills which the current study adopts.

▪ **Teaching and Developing Critical Thinking Skills:**

There have been different trends towards teaching and developing critical thinking of learners. Having surveyed a number of studies, such trends can be identified as follows (Thompson, 2011), (Chalupa, 1992):

(A) The First Trend: Direct learning of critical thinking:

According to this trend, critical thinking skills are learned in a direct and explicit way through a course content that contains many activities related to those skills but far from being related to the content of a specific course.

(B) The Second Trend: Learning for the sake of critical thinking:

Here the critical thinking skills are implicitly learned in the context of teaching the content of a certain course. For example, the teacher may use specific teaching practices such as providing the suitable environment or using specific teaching strategies when dealing with the course content, which helps in developing such skills.

(C) The Third Trend: Merging in teaching critical thinking:

According to this trend, teaching of critical thinking skills and the course content are merged in such a way that the course content is taught and at the same time used in teaching the critical thinking skills in a direct and explicit way. Hence, learners learn the course content and the critical thinking skills at the same time. *The researcher adopts the second trend in this study.*

2.3.Previous Related Studies:

The previous studies related to the present study can be dealt with in two main areas as follows:

2.3.1 Studies that dealt with the use of Elaboration Theory as an approach to teaching:

All studies in this area have concluded that Elaboration Theory is effective in enhancing academic achievement and some other variables that have direct relationship with achievement and those that have no such relationship for all learners in different stages of education, whether regarding mathematics or other courses. This gives an initial indication for the feasibility of this theory in the present study. This theory has proved effective in developing a number of important variables which are listed as follows:

- (A) Developing the consumption awareness of Egyptian women through a program in family education based on the Elaboration Theory (Rashwan, 2015).
- (B) Academic achievement and approaching the course for student teachers in the Faculty of Education, Mansoura University through a web-based program 2.0 according to the Elaboration Theory (Alsayed, 2012).
- (C) Academic achievement and deductive thinking besides approaching the course for 1st year secondary students (Omran, 2009).
- (D) Academic achievement and the skill of decision-making for blind students in the 3rd medium grade in Saudi Arabia (Foada, 2006).
- (E) Approaching learning in the curricula of physical sciences for second year students in the Department of Electronics & Computer Engineering Technology, Indiana University (English & Reigeluth, 1996).
- (F) Improving learning of scientific principles in Newton's laws of motion for university students (Riber, 1996).

2.3.2 Studies that dealt with the development of critical thinking skills:

These studies have concluded that the best methods, environments, curricula, and strategies of teaching are those that can be used to develop the critical thinking skills, as well as the relationship between critical thinking and some other important related variables. This will be made clear in the following section:

- (A) The programs, approaches, methods and strategies for developing the critical thinking skills include the following:
 - Approaches and programs based on educational enrichment activities, such as CORT programs (Abdelhamid, 2015).
 - Method of brainstorming through teaching mathematics (Alfarhood, 2015).
 - Use of teaching strategies based in their structure on those activities that contribute to the development of critical thinking skills such as the mind map strategy (Ashoush, 2015).
 - Organization of curriculum contents in accordance with educational theories with certain signification that fits the nature of critical thinking such as: Brain compatible learning theory (Almatrafy, 2014).
 - Interdisciplinary courses such as Algebra for science which is an interdisciplinary course in Algebra and Science (Elliott, et. al., 2001).
 - Encouraging learners to be acquainted with all that is new in science and find different solutions to the problems they face, as well as providing the suitable learning environment for this purpose (Kjos & Long, 1994).

- (B) Mathematics is the most suited course for the development of critical thinking and its skills, due to its special nature that makes it rich material for critical thinking. Moreover, studying modern Mathematics results in more development of such skills for learners than traditional Mathematics (Alfarhood, 2015).
- (C) There is a functional relation between learners' specialization and their ability to practice critical thinking and its skills. Learners with scientific specializations represent the first level in practicing the critical thinking, whereas those learners with technical, agricultural and industrial specializations represent the middle level, and the learners with literary specializations represent the lowest level (Abdelbaset, 2005).
- (D) There is no statistically significant correlation between academic achievement and critical thinking for talented students (Altoweigy, 2015).

3. Methodology:

In this part the researcher describes the method and procedures that were followed in the current study, as he deals with a description of the study sample, tools, and procedures to ensure validity and reliability. Moreover, he discusses the statistical treatments used in the data analysis.

3.1 Sample of the Study:

The sample of this study comprised (119) students in the fifth grade from Almanahl School in Salalah city, Dhofar Governorate, and were randomly divided into two groups. The first group was the experimental group (60 Students) and the other one was the control group (59 Students). The mathematics teacher who taught the two groups is Mr. Ahmed Darwish.

3.2 The Study Tools:

The following tools were used in the study:

3.2.1. Student's book according to Elaboration Theory:

The researcher reformulated the geometric and measurement unit to be taught to fifth grade primary students in light of the elaboration theory, according to the following steps: epitome (conceptual epitome, procedural epitome, and theoretical epitome), analogy, levels of elaboration, relating, summarizing, synthesis, and expanded epitome. To check the appropriateness of the student book for the elaboration theory, skills of critical thinking and students, this book was presented to five faculty members who teach mathematics curricula and was modified according to their suggestions.

3.2.2. Teacher's guide according to Elaboration Theory:

The researcher built a guide for mathematics teacher which explains the teaching of geometric and measurement unit using elaboration theory. This guide includes the objectives of the unit, learning aspects, critical thinking skills, teaching aids and activities, teaching steps, and evaluation. To check the appropriateness of the guide for the elaboration theory, critical thinking

skills and students, this guide was presented to five faculty members who teach mathematics curricula and was modified according to their suggestions.

3.2.3. Academic Achievement Test:

The researcher built a test to measure the students' academic achievement. This test contained (25) questions in the content of the unit, in which (20) questions are of multiple choice and (5) of problem solving type. To ensure the validity, this test was presented to seven faculty members who teach mathematics and some items were modified based on their suggestions. The degree of agreement was found to be at (87%). To check the reliability, the researcher carried out the test as a pilot study on the fifth grade students (30 students). Reliability coefficient was calculated for the test using the Guttman's equation which was found to be at (0.90). The test contained (15) questions of multiple choice and (5) questions of problem solving. One mark was given for the correct answer and zero mark for the wrong answer in multiple choice questions, and (0-2) marks in problem solving questions according to the answer of the student. Thus, the maximum score for the test is (25) marks, while the minimum is (0), taking into account that the time of the exam was (40) minutes.

3.2.4. Critical Thinking Test:

The researcher built a test in order to measure the students' critical thinking skills. This test consisted of (25) questions in the content of the unit, according to the skills of critical thinking (5 questions for every skill). To ensure the validity, this test was presented to seven faculty members who teach mathematics and some items were modified based on their suggestions. The degree of agreement was found to be at (83%). To check the reliability, the researcher carried out the test as a pilot study on the fifth grade students (45 students). Reliability coefficient was calculated for the test using the Guttman's equation and was found to be at (0.88). The final test contained (20) questions (4 questions for every skill). One mark was given for correct answer and zero mark for the wrong answer. Thus, the maximum score for the test is (20) marks, while the minimum is (0), taking into account that the time of the exam was (50) minutes.

3.3 Variables:

3.3.1 Independent Variables:

- Teaching strategy contains two levels (teaching strategy based on elaboration theory and on traditional strategy).

3.3.2 Dependent Variables:

- Academic achievement in mathematics.
- Critical thinking skills.

The table below shows these variables:

Independent Variables	Elaboration Theory	Traditional Strategy
Academic Achievement	A1	A2
Critical Thinking	A3	A4

A1: Academic achievement for the group taught by elaboration theory.

A2: Academic achievement for the group taught by traditional strategy.

A3: Critical thinking for the group taught by elaboration theory.

A4: Critical thinking for the group taught by traditional strategy.

3.4. Study Design:

A1	S1	M1	M2
A2	S2	M1	M2
A3	S3	M1	M2
A4	S4	M1	M2

M1: Performance on the pre-test of achievement in mathematics, and critical thinking skills.

M2: Performance on the post-test of achievement in mathematics, and critical thinking skills.

S1: Treatment for the first group (achievement -elaboration theory).

S2: Treatment for the second group (achievement - traditional strategy).

S3: Treatment for the third group (critical thinking -elaboration theory).

S4: Treatment for the fourth group (critical thinking - traditional strategy).

3.5. Experimental Treatment:

The primary school students were exposed to the mathematics content according to the elaboration theory in order to investigate the effectiveness of teaching mathematics for the development of the achievement and critical thinking. The study was carried out in 25 times during 5 weeks. The experimental and control groups were pre-tested, then experimental groups were taught the geometric and measurement units by the mathematics teacher (Mr. Ahmed Darwish) using teacher's guide according to elaboration theory, and the control group was taught the same unit by the same teacher using traditional strategy. At the end of the application period, the students were post-tested in achievement and critical thinking.

3.6. Statistical Treatment:

Data were analyzed using means, standard divisions, and T test

4. Results:

The study aims to formulate the content of mathematics curriculum at the level of primary school students according to the elaboration theory, and measure the effectiveness of this mathematics content to develop the academic achievement and critical thinking skills.

The study questions are:

1. What is the effectiveness of Elaboration Theory in the development of mathematical achievement for primary students in Dhofar?
2. What is the effectiveness of Elaboration Theory in the development of critical thinking skills for primary students in Dhofar?

The hypotheses below emerged from the above questions:

1. There is no significant difference at (0.05) between the academic achievement of the experimental group and that of the control group.
2. There is no significant difference at (0.05) between the critical thinking skills of the experimental group and those of the control group.

To answer these questions, and verify the hypotheses, the following has been done:

4.1 Pre -test:

To know the significance of differences between the two groups for the academic achievement and critical thinking skills in the pre-test, T test has been used, as shown in Table(1).

Table (1) Significance of differences between the two groups in the pre-test using T test

Achievement and Critical Thinking	Experimental Group			Control Group			T test	Sig.
	N	Mean	Std. Div.	N	Mean	Std. Div.		
Achievement	60	3.29	1.77	59	3.21	1.53	0.24	1.46
Critical Thinking	60	4.63	2.34	59	5.08	2.20	0.99	1.11

Table (1) illustrates that there was no significant difference between the experimental group and control group in the pre-test of the achievement test and critical thinking test. This shows that the two groups (experimental and control) are equal in achievement and critical thinking before the beginning of the experiment.

4.2 Post-test:

4.3

To know the significance of differences between the two groups for the academic achievement and critical thinking skills in the post-test, T test has been used, as shown in Table(2).

Table (2) Significance of differences between the two groups in the post-test using T test

Achievement and Critical Thinking	Experimental Group			Control Group			T test	Sig.	η^2
	N	Mean	Std. Div.	N	Mean	Std. Div.			
Achievement	60	22.30	5.07	59	16.02	3.39	7.22	0.000	0.32
Critical Thinking	60	16.13	7.34	59	10.27	6.01	4.34	0.001	0.37

The previous table shows the following:

- There are substantial differences in the mean grades of the experimental group and the control group in the academic achievement test and critical thinking skills in favor of the experimental group.
- There are significant differences at (0.05) between the mean grades of the experimental group and the control group in the academic achievement test and critical thinking skills test in favor of the experimental group.
- The effect size (η^2) of the elaboration theory on the achievement and critical thinking skills was high. It can be said that the organization of mathematics content in accordance with the elaboration theory led to the development of each of the achievements and critical thinking skills for the participants of the study.

The results mean that the hypotheses are not accepted, and the alternative hypotheses are accepted, which indicates that:

- There is a significant difference at (0.05) between the academic achievement of the experimental group and that of the control group in favor of the experimental group.
- There is a significant difference at (0.05) between the critical thinking skills of the experimental group and those of the control group in favor of the experimental group.

5. Discussion:

The results of this study can be attributed to:

- Organizing the mathematics content according to the elaboration theory makes it compatible with the organization of knowledge in the minds of students, resulting in the development of academic achievement and critical thinking.
- Elaboration theory was adopted to provide details of the new information, making it meaningful, and effectively employed in other educational operations and contexts.
- Elaboration theory was adopted to provide for students analogies familiar to the content of the lesson, which makes it easy to learn without the occurrence of errors in understanding.
- Elaboration theory focused on linking information to each other, which helps students to understand the relationships between the information and the exercise of critical thinking skills, such as: interpretation, classification, discrimination, deduction, conclusion, and evaluation.

However, many studies have found that academic achievement and critical thinking skills can be developed by using other approaches through teaching mathematics, such as: (Alfarhood,2015), (Abdel Hamid, 2015), (Almatrafy, 2015), (Alsayed,2006).

6. Recommendations:

Based on the results of this study the researcher recommended preparing the content of mathematics curriculum at the basic stage of education in accordance with the principles of elaboration theory and improving the mathematics teachers' performance to develop critical thinking skills for their students. More research should be conducted to identify the effect of using elaboration theory in the teaching of mathematics on other variables, and prepare a comparative study on the effect of using elaboration theory and other theories on teaching mathematics in other educational stages than the one examined in this study.

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