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THE EFFECT OF USING GENERATIVE LEARNING STRATEGY ON THE ACADEMIC ACHIEVEMENT AND MATHEMATICAL THINKING OF PRIMARY SCHOOL PUPILS

HAMAD MUIDH M. AL MUTLAQ
General Administration for Education in Najran, Saudi Arabia
Email: h-almutlaq2022@hotmail.com

ABSTRACT: *The present study aimed to identify the effect of using the Generative Learning strategy on the development of the academic achievement and mathematical thinking skills of primary school pupils. Moreover, it tried to identify what kind of correlation exists between pupils' academic achievement and mathematical thinking because of the use of the Generative Learning in teaching. The quasi-experimental approach was used. The main study instruments were an achievement test in addition to a test for pupils' mathematical thinking skills. Furthermore, the study was applied to (58) pupils in the sixth grade in a school in Najran city in Saudi Arabia. Findings showed that the use of Generative Learning strategy was very effective in developing both, the academic achievement and mathematical thinking skills of participant pupils. Meanwhile, the study revealed insignificant correlation between pupils' achievement and mathematical thinking skills due to the use of Generative Learning strategy.*

KEY WORDS: Generative Learning; academic achievement; mathematical thinking; thinking skills; mathematics

INTRODUCTION

Mathematics has an intrinsic role in community forming and shaping. It occupies a fundamental place among other branches of science. It is one of the basic curricular materials that are inevitable in the educational process because its teaching aims to provide learners with the mathematical knowledge in addition to the development of thinking skills such as induction, deduction, inference, knowledge of fallacies, visualization, generalization, and discovery (Al-Kbaisi & Abdel Hafez, 2019). However, different studies have showed that students are still facing difficulties and their academic achievement levels are low and not convincing despite this prestigious and important role it has (Ibrahim, 2016; Najjar & Dawoud, 2013; Al-Mansour, 2011; & Al- Astal, 2010). Moreover, low and dissatisfying levels of achievement in mathematics might be due to a set of causes like for instance, the learner's poor knowledge of the basic competencies in mathematics, lack support of school atmosphere, teachers and all other stakeholders. Likewise, the weak linkage of mathematics curricula with real life contexts and the focus of the teaching methods on the superficial learning instead of meaningful learning might be other critical causes (Al-Othmani, 2015).

On the other hand, lack of interest to develop the learner's mathematical thinking is one serious challenge facing mathematics teaching and learning. There is randomness in thinking methods and steps when students try to prove certain mathematical matter or theory (Obaid, 2013). Besides, students' weakness in language skills, prior knowledge related to concepts in mathematics, and participation in mathematical activities are all factors causing the learners' mathematical thinking, (Al-Asmar, 2008). Thus, The National Council of Mathematics Teachers in the United States of America has stressed the need to work on developing students' mathematical thinking, critical thinking, and mathematical proof. It also has stressed the importance of improving the learners' inductive and deductive thinking, inference, mathematical proof, and expression using symbols. The council also has encouraged presenting mathematics as a tool for thinking and communication that helps students to be thinkers, not knowledge recipients (NCTM, 2000).

Thus, many trials have been made to change the idea of constructivism into actual teaching actions where each action has a big value for the educational process. Constructivism is a recent educational vision that focuses on what happens inside the learner’s mind when exposed to educational situations such as his previous knowledge, ability to process information, motivation for learning and thinking style. It is based on the fact that everything, the learner does, become meaningful to him (Zaitoun, 2007). Furthermore, Constructivism is based on the learner's self-construction of meaning by his cognitive apparatus and can not be transferred to him by the teacher. Meanwhile, meaning formation, for the learner, is an active constructive process that requires mental effort. The learner feels comfortable for keeping the cognitive meaning in his mind balanced as long as experience data are in line with what he expects.

Thus, Generative Learning is one of the prominent teaching strategies and models of mathematics based on constructivism. It is a strategy based on the activation and stimulation of brain to recall previous concepts and link them with concepts to be learned in order to form new concepts and cognitive structures (Al- Zahrani, 2018). It includes a set of generative processes, which the learner carries out to link both new and previous information in his cognitive structure. Generative Strategy, on the other hand, is concerned with generating meaningful relationships between newly and previously learnt information. The interest of generative learning is mainly focused on the cognitive structures stored in the learner’s memory and on the basis of which tangible inputs are selected and paid attention to. It is also interested in the relationships generated between stimuli, the learner is exposed to and patterns of storing in the learner’s cognitive structure. Meanings produced by tangible inputs and information, as well as evaluation of these meanings are also paid much attention (Al-Najdi & Abdul-Hadi, 2005).

Constructivism

Constructivism is an epistemological vision where reality is constructed by one's knowledgeable self (Al- Najdi & Abdel hadi, 2005). That is, knowledge is not just a copy or image of reality, but it results from building reality through this

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knowledgeable self. Constructivism is also a social process in which learners interact with objects and events through their senses that help link their prior knowledge with the new knowledge including beliefs, ideas and images (Zaitoun, 2007. Besides, constructivism is a philosophy based on the learner's active and meaningful knowledge building through his previous experiences. It is a social negotiation with peers that emphasizes the active role of the learner in the presence of the teacher as facilitator to build meaning properly in an environment conducive to learning (Al-Asmar, 2008). It can be defined as an interaction between previous and new knowledge, which students acquire through their interaction with environment. Thus, Constructivism allows students the chance to build cognitive systems to explain the phenomena and events they live and experience (Al-Khatib, 2009). A more developed view of constructivism views it as a theory based on the idea that the learner is active by nature and is able to create a cognitive environment by linking new information with his previous knowledge (Ali, 2011). Another recent definition of constructivism deals with it as an educational methodology where the learner builds his own knowledge in the presence of his teacher based on his previous knowledge. In short, constructivism can be referred to as an interaction between the learner's background knowledge and the newly acquired ones via his interaction with the surrounding environment where he builds his own cognitive system by which he interprets the environmental phenomena he lives in (Al-Wali, 2015).

Generative Learning

Generative Learning model was used for the first time by Osborn and Wittrok in 1985 as an educational learning model. Learners, in this model, use their cognitive structures to link their newly acquired information with their previous knowledge in their cognitive structure. Generative Learning, as a strategy, allows the learner to generate meaningful relationships and so the generative strategy is interested in generating meaningful relationships between new and previous information. Therefore, background knowledge is necessary for building meaning and interaction between both types of knowledge. It is a core component in meaningful learning process (Al-Najdi & Abdul-Hadi, 2005). Moreover, Generative Learning in teaching mathematics aims to accomplish a set of aims (Zaitoun, 2007) like for instance:

1. Support pupils with educational learning situations where they can form new experiences, and link ideas with the phenomena under study.
2. Activate the learner's brain by creating reasonable relationships to build real foundations based knowledge that raise and develop the learner's ability to understand educational situations.
3. Develop the learner's metacognitive thinking that makes his brain active and helps others to define their ideas through empirical evidence and critical situations.
4. Create a conceptual change in the learner's structure to increase his ability to face daily life situations and the clarity of cognitive ideas.

Furthermore, Generative Learning is based on these five main processes (Abdul Radi, 2003; Affaneh & Al Jaish, 2008; & Abed Al-Majeed, 2015).

1. Knowledge, experience and concepts where the teacher explores the learners' concepts, beliefs, and previous experiences related to natural events and phenomena necessary to learn new concepts.
2. Motivation where the teacher motivates learners by taking responsibility for learning while carrying out various activities that lead them to delete incongruity between their knowledge and beliefs, on one hand and the concluded attributes of concepts, events and phenomena, on the other hand.
3. Attention where the teacher guides his learners' attention through questions to focus their attention on meaning construction and scientific concepts' explanation. In this process, events and phenomena description is used as a means of generating the structure of information.
4. Generation, which is the essential stage in Generative Learning strategy. The teacher has to understand that the goal of science education is not to review the scientific material and the views of scientists about natural events and phenomena. It is generating meanings and relationships through exerting efforts, using concept maps, drawings, illustrations and presentations.
5. Metacognition where the teacher guides his pupils to use their thinking skills and mental processes to understand the scientific concepts and then apply them to their new contexts.

Mathematical Thinking

Mathematical thinking is not like other types of thinking because it includes precisely defined terms regarding the relationships between numbers, symbols and concepts that can be represented, either by drawing or other forms. Mental activities are the base for the development of this type of thinking. Its nature can be defined into three elements (John Le Blanc cited in Al-Khatib, 2009):

1. Categorization: classification into groups with common characteristics.
2. Arrangement: discovering the prevailing system in a group by describing its content.
3. Matching: discovering identical relationships between the units of different groups.

Moreover, mathematical thinking is a compound capacity that involves (Al- Saidi, 2016):

1. Numerical ability consisting of perception of numerical relations, dependencies and additions.
2. Inferential ability consisting of both induction and deduction.
3. Spatial ability appearing in every cognitive mental activity characterized by visualization of flat and solid shapes movement. It includes both dual and triple spatial abilities.

In addition, mathematical thinking can be divided into two main levels, low level of mental abilities, i.e. comprehension and higher level of mental abilities, i.e. careful thinking, inductive thinking, and analogical reasoning (Al-Khatib, 2009).

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Skills of Mathematical Thinking

Skill, some years ago, was defined as the learner's ability to interpret, define, understand, and practice mental processes easily, perfectly and accurately (Habib, 2016). It is the ability to perform well in a certain context after training and exercising accompanied by a change in behavior (Al-Mansour, 2011). Mathematical thinking skill, in turn, is the learner's ability to perform all subskills quickly and perfectly to solve a problem or make a decision (Ghanem, 2018).

With regard to skills of mathematical thinking, it can be argued that generalization, induction, deduction, expression by symbols, formal logic, visualization, and mathematical proof are the main skills (Abu Zainah, 2010). Another set of skills might involve inductive thinking, deductive thinking, symbolical thinking, probable thinking, relative thinking, spatial awareness, visualization and mathematical proof (Al- Khatib & Ababneh, 2007).

To conclude, we can say that mathematical thinking is a mental activity related to mathematics. Students are to practice this kind of thinking to solve problems in mathematics, explore and discover logically. It has different forms and can be revealed by grades, students obtain, when they are subjected to an exam prepared for this sake.

Statement of the Problem

Findings of scientific research and studies conducted in the Arab world generally and more specifically in Saudi Arabia indicate that school students suffer from critic problems and difficulties while learning mathematics. Their academic achievement levels are the best evidence for this suffering despite the efforts exerted by stakeholders of the educational process and the importance that mathematics has all over the world (Al-Kbaisi & Abdul Hafiz, 2019; Ibrahim, 2016; Najjar & Dawoud, 2013; Al-Mansour, 2011; and Al-Astal, 2010).

Therefore, the present study aims to identify the effect of using Generative Learning strategy in the development of the academic achievement and mathematical thinking of sixth grade pupils in Najran City, in Saudi Arabia.

Questions of the Study

The present study aims to answer these questions:

1. Is there any statistically significant effect for the use of Generative Learning strategy to teach mathematics on developing the academic achievement of sixth grade pupils?
2. Is there any statistically significant effect for the use of Generative Learning strategy to teach mathematics on developing the mathematical thinking skills of sixth grade pupils?

3. What is the kind of relationship between the academic achievement and mathematical thinking of the sixth grade pupils due to the use of Generative Learning strategy?

METHODOLOGY

Study design

The quasi-experimental approach was used in the present study. Participant pupils in the experimental and control groups were subjected to both achievement and mathematical thinking pre-tests to ascertain their equivalence before conducting the study. Figure 1 shows the study design.

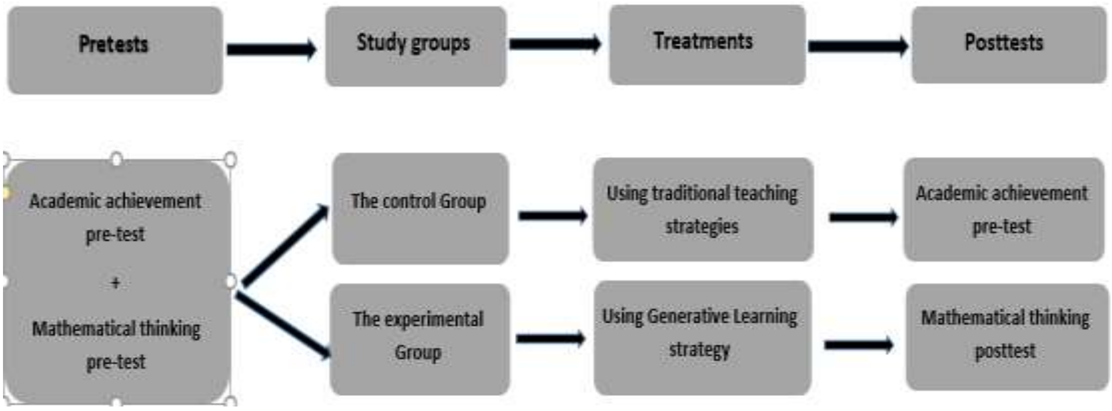

Figure 1: Study Design

Study Population and Sample

The Population

Population of the present study consisted of all sixth primary graders in all elementary schools in Najran region that were enrolled in studying mathematics in the first semester of the academic year 2019/2020. Their total number was (4080) pupils and they were either eleven or twelve years old.

The Sample

The sample, in the present study, consisted of (58) pupils who were all in the sixth grade and were studying at Al-Bara'a Bin Azeb elementary School in Najran city in Saudi Arabia. They were previously divided by school administration into two groups, Group A and group B. Group A (N=28) was assigned as control group and was taught the chosen units of their mathematics textbook by using the traditional strategies. Meanwhile, Group B (N=30) was assigned as experimental group and was taught the same units via the use of Generative Learning strategy.

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Instruments

The Achievement Test

An achievement test in two chosen Modules, i.e. Regular Fractions Module and Decimal Fractions Module, was developed. The main aim of this test was to check pupils' level of achievement in concepts and relationships like length, mass, and capacity.

Test Validity

To ascertain the validity of the test, it was, in its primary version, presented to a jury of faculty members who were all specialists in curriculum and teaching methods, in addition to some mathematics teachers and educational supervisors. They were all requested to check belonging and suitability of each item to the objective it aimed to achieve. The total number of all items in the final version of the teat were (30) items, after consideration of the jury's recommendations.

Test Reliability

To check the test reliability, it was applied to a pilot sample of (30) pupils. Using Cronbach Alpha, the correlation coefficient was (0.67) indicating that the test was reliable and fit for the study.

Mathematical Thinking Test

A test was prepared to measure participant pupils' mathematical thinking skills. It mainly involved three main skills. Each main skill had (5) items, and so the total number was (15) items.

Test Validity

To ascertain the test validity, it was, in its primary version, presented to a group of specialists including some faculty members who were all specialists in curriculum and teaching methods and some mathematics teachers and educational supervisors.

Test Reliability

To check the test reliability, it was applied to a pilot sample of (30) pupils. Using Cronbach Alpha, the correlation coefficient was (0.67) indicating that the test was reliable and fit for the study.

Homogeneity of Participants' Academic Achievement before the Experiment

To make sure that the two groups were equal in their academic achievement before conducting the study, participants were subjected to the achievement pre-test. Results are presented in Table 1.

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Table 1: **Significance of the differences between participants' mean scores**

Group	N	M	SD	N	T	Significance (α=0.05)
Control	28	7.12	1.95	58	0.78	Not significant
Experimental	30	7.3	2.15			

Table 1 shows that there were no significant differences between the mean scores of participant pupils in both groups due to the use of either Generative Learning strategy or the use of traditional teaching methods. That is, knowledge and achievement of pupils in both groups, with regard to the regular and decimal fractions, length, mass and capacity were equal and homogenous.

Homogeneity of Participants' Mathematical Thinking Skills before the Experiment

To make sure that the mathematical thinking skills of pupils in both groups were equivalent before conducting the study, a test was carried out. Findings are shown in Table 2.

Table 2: **Significance of the differences between participants' mean scores**

Group	N	M	SD	DF	T	Significance (α =0.05)
Control	28	3.35	1.31	56	1.16	Not significant
Experimental	30	3.90	1.91			

Table 2 shows that there were no significant differences between participant pupils' Mathematical thinking skills in both groups due to the use of either Generative Learning strategy or traditional teaching methods. That is, pupils' thinking skills in both groups were equal and homogenous.

FINDINGS AND DISCUSSION

Results Related to the First Question

To answer the first question "*Is there any statistically significant effect for the use of generative learning strategy to teach mathematics on developing the academic achievement of sixth grade pupils?* T. test for the differences between the two groups was used. Results are shown in Table 3.

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Table 3: **Significance of the differences between participants' mean scores**

Group	N	M	SD	DF	T	Significance (α=01)
Control	28	14.1	2.59	56	6.2	Significant
Experimental	30	19.6	3.97			

Results in Table 3, indicate that there were significant differences between the mean scores of participant pupils in both groups in favor of pupils in the experimental group who learnt the chosen modules of regular and decimal fractions through the Generative Learning strategy. In other words, the achievement of pupils in the experimental group was superior to the achievement of their peers in the control group. Therefore, Eta Square (η^2) was used to identify the effect size of the Generative Learning use in the development of pupils' academic achievement in mathematics. Table 4 shows the results.

Table 4: **Eta Square (η^2) for the effect size of the Generative Learning strategy**

T. Value	Square of T. Value	DF	Eta Square (η^2)	Effect Size
6.2	36.4	56	0.39	Big

With reference to literature about the values of Eta Square (η^2), it can be claimed that the effect size of using the Generative Learning Strategy was very big on the improvement of participant pupils' achievement in mathematics. Thus, it can be concluded that the use of Generative Learning strategy was effective in the enhancement of pupils' academic achievement in mathematics.

This result, with regard to the effect of Generative Learning strategy on the improvement of pupils' academic achievement, is in congruence with the findings of Al-Zahrani (2018); Sari (2018); Al-Shammari (2018); Al-Ibriyah (2017); Al-Otaibi (2017); Al-Saiadi (2016); Al-Hasani (2015); Saifin (2015); and Al-Kbaisi & Al-Saidi (2012). Superiority of pupils' performance in the experimental group, who studied the selected two modules using Generative Learning, represented by their good achievement in mathematics might be interpreted in light of:

1. Pupils' active role where they positively generate, but not transfer new knowledge depending on their background knowledge, which in turn facilitated its retention.
2. Pupils' application of knowledge through using generative learning strategy that led to expanding the concept extent and achieving the functional aspect of knowledge in their daily lives.
3. Correlation that takes place between pupils' stored knowledge in their long term memory and their newly accepted information in their short term memory.

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4. Practice of varied and numerous activities through the use of Generative Learning strategy, which created a type of positivity leading pupils to accomplish better achievement levels.
5. The environment related assignment gave value and appreciation to the learning content that led to an increase in pupil's achievement level.
6. Reliance, through the steps of Generative Learning, on pupils' background knowledge, motivation, concentration on the learning tasks, produced more accurateness and better achievement when addressing learning.
7. Feedback and motivation caused pupils to exert effort to obtain and generate knowledge that, in turn resulted in better learning and achievement.
8. The use of aids like images, drawings, computer, and different learning scaffolds helped introduced information in a concrete way that can be remembered easily.

Results Related to the Second Question

To answer the second question "*Is there any statistically significant effect for the use of generative learning strategy to teach mathematics on developing the mathematical thinking skills of sixth grade pupils?* T. test for the differences between two groups was used. Table 5 shows the results.

Table 5: **Significance of the differences between participants' mean scores**

Skill	**N**	**M**	**SD**	**DF**	**T**	**Significance (α=01)**
Mathematical thinking skills as a whole	28	7.46	1.8	56	5.7	Significant
	30	10.5	2.2			

Results in Table 5, indicate that differences between the mean scores of pupils in both groups were statistically significant. Significant differences were, of course in favor of pupils in the experimental group who studied via the use of Generative Learning strategy. That is, skills of mathematical thinking of pupils in the experimental group were developed better than the skills of their peers in the control group. Therefore, to identify the effect size of using Generative Learning strategy on the development of pupils thinking skills, Eta Square (η^2) was used. Table 6 shows the results.

Table 6: **Eta Square (η^2) for the effect size of the Generative Learning strategy**

T. Value	**Square of T. Value**	**DF**	**Eta Square (η^2)**	**Effect Size**
5.7	25.49	56	0.31	Big

Results in Table 6, in accordance with Eta Square (η^2) values, prove that the effect size of using Generative Learning Strategy was very big on developing the mathematical thinking skills of pupils in the experimental group. Therefore, superiority of pupils' mathematical thinking skills in the experimental group could be

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due to the fact that Generative Learning strategy was more effective than other traditional teaching methods in raising the levels of participants' mathematical thinking skills.

This result, to a great extent, corroborates the findings of Sari (2018); Al-Othmani (2015); Al-Qroon (2018); Rayyan (2016) and Abu Shair (2015). Superiority of pupils' performance in skills of mathematical skills can be referred to a set of facts like:

1. Pupils' motivation to learn that was raised by the use of Generative Learning strategy.
2. Pupils' responsiveness to Generative Learning and enjoyment in its stages as a new educational method.
3. Excitement pupils experienced while practicing the skills of mathematical thinking that helped them to explore their potentials.
4. Appreciation that was granted by Generative Learning to each pupil as each one performed his role with regard to his thinking and ability to interact with his peers in the group.
5. Meaningfulness of Generative Learning, which that increased the academic achievement of each pupil as a result of applying what was learnt in his daily life.
6. Positivity of the teacher's role that created positive interaction between pupils themselves on one hand, and between pupils and the learning material, on the other hand.
7. Self-evaluation that was granted by Generative Learning to each pupil that generated his ability for self-learning by linking the newly learnt concepts with his previous knowledge.

Results Related to the Third Question

To answer the third question "*What kind of relationship is between the academic achievement and mathematical thinking of the sixth grade pupils due to the use of Generative learning strategy?*" Pearson correlation coefficient was used. Results are presented in Table 7.

Table 7: **Pearson Correlation Coefficient between achievement and mathematical thinking**

Dependent variables		**Academic Achievement**	**Mathematical thinking**
Achievement Test	Pearson Correlation Coefficient	1	**0.254**
	Sig. (2-tailed)	---	0.55
	N	58	58
Mathematical Thinking test	Pearson Correlation Coefficient	**0.254**	1
	Sig. (2-tailed)	0.55	---
	N	58	58

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Results in table 7 show that there was a weak positive correlation (0.254) between the academic achievement and mathematical skills of pupils in the experimental group due to the use of Generative learning strategy. This insignificant correlation could be referred to a set of factors:

1. Pupils' weakness in using mathematical thinking skills in general.
2. Insufficient training and time to use the skills of mathematical thinking.
3. Inadequacy of the curriculum used for applying the skills of mathematical skills.

CONCLUSION

The present study aimed to identify the impact and efficiency of Generative Learning model on the development of sixth grade pupils' achievement and thinking skills in mathematics. Results were to some extent, encouraging and significant in comparison with the achievement and thinking skills of peers in the control group who were taught via a traditional teaching strategy. Therefore, these results with regard to the development in participant pupils' level of performance while learning the chosen modules assert the need for more training workshops and courses for teachers of mathematics to empower them to develop students' mathematical thinking skills. School libraries, on the other hand, should be provided with modern scientific references and periodicals that deal with modern teaching strategies, especially Generative Learning to be used by teachers and learners. Meanwhile, the learning environment should be developed to be more effective and attractive for pupils by providing modern teaching means and techniques that suit modern teaching strategies especially constructivism .

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