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The Impact of Using the LEGO Education Program on Mathematics Achievement of Different Levels of Elementary Students

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Abstract: This study aims to investigate the impact of using a LEGO Education program, specifically the “MoreToMath” kit, on the achievement of Different Levels of Elementary Students. The quantitative research design was used in this research study, and the participants were comprised of 120 elementary school students in the 2nd grade, in Amman, Jordan. A quasi-experimental research method and the MANCOVA were used, and a study tool to measure achievement was developed by the researcher for which the validity and reliability of achievement were verified. The results of the study show that there was a statistically significant improvement ($\alpha \leq 0.05$) in the achievement of the experimental study group, that studied using LEGO education, over the control group. There is also a statistically significant difference ($\alpha \leq 0.05$) between the arithmetic means of the three sub-groups of students’ previous achievement levels— high, middle, and low— and by using the Least Significant Differences (LSD) test we notice that there are significant differences between the high and low sub-groups, as well as between the middle and low. However, that there are no significant differences between the high and middle level sub-groups; and there is also no statistically significant interaction between the groups (experimental, control) and the levels of pre-achievement seen in the post-achievement levels. The study results indicate that the use of new technological tools, like the “MoreToMath” kit, may be beneficial in teaching mathematics as they tend to motivate students, and can lead to higher achievement for elementary students of different mathematics aptitude levels.

Keywords: Mathematics, LEGO education, achievement, “MoreToMath” kit (MMK).

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Introduction

There are many struggles faced in teaching mathematics in Jordan, and these include decreasing levels of motivation among students, inadequate teaching strategies used in the subject, and deficient problem solving strategies used by teacher and learner alike. It is very important to individualize the teaching approaches with respect to the differences between students, such as the different levels of aptitude or previous achievement, academic intelligence, mental capacity, and preparedness to learn; and this individualization is especially important when dealing with students who have learning disabilities in mathematics. It is key to explore and develop new programs to engage students in their unique ways of learning.

There are many entities and advocates around the world that are concerned with recognizing these individual learning differences, and who champion learning equity and the rights of the child, in order to provide all children with the right opportunities for teaching and learning. Birthed out of these concerns were the universal standards described in the No Child Left Behind (NCLB) Act in 2001, which requires the assessment of students in mathematics and linguistics skills (Etscheidt & Curran, 2010).

As modern technology accelerates in its reach and capabilities, it becomes more and more prudent to merge this dynamic technology in teaching, and to use emerging tools and programs to solve mathematics problems. This merging of technology, new sciences, and practical integrated programs in curricula yields genuine opportunities for learners to study mathematics through games and the stimulation of their faculties, and positively impacts on their acquisition of direct experiences and skills (Mustafa, 2018). In fact, the National Council of Teachers of Mathematics (NCTM, 2000) stresses the importance of integrating technological tools in education, as they may supports the personalized learning of students and can be adapted to any curricula to improve the retention of mathematics lessons.

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These tools can be intuitively used in line with Bruner's theory of learning, which emphasizes the need to teach the concepts and skills of mathematics in the three representational stages of the concrete, then the pictorial, and finally the abstract. Bruner's theory of learning is interested in constructing knowledge by using the discovery method of concepts and principles, which presents curriculum knowledge in a way that develops and supports the individual learner by linking new facts with previous information; and this leads the learner to acquire knowledge from its smaller components to the whole, and thus to build a stronger knowledge base (Qatami, 2005). Bruner determines how groups of information are processed for optimal, efficient learning, which is based on acquiring the information with a certain continuity and sequencing of concepts. Following that process ensures changing the acquired information to useful knowledge, which involves understanding and retaining it; and this aids in constructing an integrated personality cognitively, emotionally, and in the form of necessary skills (Khidar & Khalaf, 2008).

LEGO Education introduces new technological tools that are in line with Bruner's theory, as inspired by and adapted from the work of John Dewey that emphasized the importance of learning with doing (Parker & Thomsen, 2019). The hands-on learning strategy of LEGO Education involves the use of groups of blocks, in many colors and volumes, which help the students to learn by constructing concrete shapes and patterns that serve as the direct and tangible experience stage of learning. The purpose is to have the learners be active, engaged, and motivated to learn, while also developing important skills in problem solving, creative expression, critical thinking, collaboration, and communication (Chu et al, 2017).

The LEGO Education tools can be considered to be some of the more appealing methods to help students master the mathematics operations of addition, subtraction, multiplication, division, ordering, sorting; as they provide a rich, adaptable environment which is built on the direct experience of the learner. The more exciting nature of this educational environment may better encourage the students to solve problems, understand concepts, and increase their ability to collaborate and communicate (Park et al, 2016).

Ever since the introduction of those color plastic blocks in 1940's Denmark, which can be assembled and reassembled in seemingly infinite possible shapes, LEGO has gone on to become very popular with children all over the world. This prompted the manufacturer to integrate its products into various curricula to allow teachers to use them in their classrooms. Thus, LEGO has evolved into a global phenomenon that has influenced many areas, particularly the area of education. There are many benefits to education with LEGO tools, such as helping to develop children's lateral and three-dimensional thinking by using constructions to reach a solution, all the while promoting children's methodologies for solving problems and organization in an enjoyable environment.

Mathematical skills are an important foundation for student education, because they help learners to understand universal concepts and generalizations that are key to carrying out life activities. It is vital to children's life development, therefore, to increase the ability to solve mathematical problems and do mental calculations easily (Arab Open University, 2013). There are many research studies on the importance of using integrated strategies and technological tools in teaching mathematics. One such study was conducted by Herro and Quigley (2016) about the teaching practices of a teacher of sixth grade students using the integrated approach, which is presented as an example of professional development in the field of modern teaching strategies. The strategies used were in the form of educational projects designed to develop students' development of integrated entrance skills, and the study discusses the challenges of teaching using such an integrated portal of knowledge.

Polianskaya (2018) conducted study about the importance of playing as a teaching strategy for early stage students acquiring basic skills in the curriculum, through the use of LEGO tools. The researcher emphasizes the importance of using the senses in education, and states that students may favor and come to depend on this type of learning because it hinges on a student's personalized and direct experience utilizing the tools and pieces that LEGO provides. To this effect, LEGO Education introduced the "MoreToMath" kit to teach mathematics, which they maintain makes mathematics skills tangible, promotes students' abilities to address their own learning problems, and helps pupils to understand mathematics creatively.

Jaber and Alzobi (2018) conducted a study on the impact of complementary activities on science, technology, engineering and mathematics (STEM) teaching, where they explored their effects on the development of pedagogical knowledge and self-esteem of elementary stage math teachers. The study was conducted on 50 teachers in Nablus, and the results showed a positive impact to those activities, as integrated with STEM instruction, in the development of pedagogical knowledge and self-esteem of mathematics teachers.

Sumen and Calisici (2016) looked at the impact of the use of the STEM educational methods in the development of the conceptual maps of pre-service, student teachers in Turkey, as well as their attitudes towards it and its impact on their students. The study was applied to 42 student teachers, as implemented in a course on the environment and its problems. The results of this qualitative study showed positive integration of STEM educational practices when exploring those teachers' conceptual map development, leading to improvements in conceptual knowledge retention, the ability to communicate, and in increased student activity within the classroom.

A similar study sought to learn the views and practices of science, engineering, mathematics, art, and technology (STEAM) teachers about the education method in South Korea, in private and governmental schools (Park, et al, 2016). The results of the study showed that teachers who have experience in teaching have positive attitudes toward education using the STEAM method, but that there are challenges faced in teaching with regards to proper time allocation, planning, and implementation.

Herro and Quigley (2017) conducted a study to examine the views of mathematics and science teachers and their practices within classrooms in America. The researchers sought to explore the importance of their participation in activities that support their professional development in the use of the STEM strategy, activities that took the form of economic, political, environmental, social, and historical projects. Digital media was used to communicate with participants to collect data and information. The results showed that teachers had generally gained increased knowledge about a content teaching system and considered this a first step to change their teaching practices.

Jamil et al. (2018) explored the beliefs of early childhood teachers who attended a professional development conference on the STEAM teaching model, with an emphasis on the integration of art into the STEM model through problem-based learning to better engage students and encourage them to think deeply. The results show that teachers differ in their beliefs about STEAM and the perceived assistance necessary to successfully implement this model, all of which may serve as obstacles towards the success of its use.

As seen above, educational systems are continually pursuing to develop mathematical skills in students, and this is especially of importance in the primary stage. Hence, there is a push towards the introduction of modern strategies and tools to help master basic skills, promote understanding of concepts, and foster the innate ability to solve problems. Perhaps the tools of learning as provided by LEGO may help us address the educational problems facing elementary school students.

Study Description

This study is centered on exploring the impact of the educational strategy of using LEGO tools in the achievement of elementary school students in mathematics, in Jordanian schools.

Study Problem:

The results of the Trends in International Mathematics and Science Study (TIMSS) indicate a low level of achievement in mathematics for Jordanian students. In fact, the Jordanian student achievement rates in 2015 were lower than the international average, and their marks were low compared to those in developed countries.

Students in the primary educational stage may generally suffer from learning problems related to basic skills such as addition, subtraction, multiplication, and division. These skills are fundamental and essential to students' educational futures. Also, in my observations as a math teacher of elementary school students, they tend to forget the skills required very quickly, and they are unable to properly retain the necessary processes and procedures if they were taught them without thorough understanding. For example, students are taught to memorize multiplication tables without understanding the process or the concept of multiplication, and strategies needed. The student may answer to " 6×7 " with "42", but is not aware of the underlying operation to get to that answer, and would likely not hold on to that information.

Study Questions:

1. What is the effect of using the MoreToMath kit of LEGO Education on the achievement scores of elementary students in mathematics?
2. What is the effect of the pre-achievement levels of elementary students in mathematics on their consequent achievement in mathematics?
3. Is there any interaction between the used educational strategy and previous achievement levels of students on post-achievement of elementary students in mathematics?

Study Importance:

The study seeks to confirm the importance of using modern tools, and interesting strategies, in teaching mathematics. By that token, the LEGO tools can be used in teaching numbers and their operations, and mathematics skills and concepts in all subjects of mathematics, such as algebra. The tool can be very valuable in motivating students, and this researcher believes it can be used to properly learn mathematics, in a comprehensive way, by developing the collaboration and problem solving skills of students.

One of the key features of the LEGO tools is that they may be available in any home, and the learner can employ them to learn mathematics easily and at their own pace.

Ultimately, this study is important because it aims to improve the achievement of elementary students in mathematics, and to address the educational difficulties that they face in mastering mathematical skills. The aim is to provide elementary school teachers and educators with tools to help them communicate ideas and concepts directly to students.

Methodology

Participants:

The study sample consisted of 120 second grade students in Amman private schools, which was divided equally and randomly into the experimental and control groups— 60 students in each. Each of two groups were divided into three levels (high achievement, middle achievement, and low achievement) according to the students' marks in the first grade.

Research Instrument:

MoreToMath Kit (MMK): a LEGO Education mathematics kit which the researcher considered to be very powerful in developing the understanding of mathematics concepts and skills. This was the set of tools that was used in the experimental groups. The skills covered are counting in descending and ascending order, addition, subtraction, multiplication, division, sorting, modeling, patterns recognition, and classifying shapes. The tools contain the studs (1*1), (1*2), (2*2), (3*3), and so on.

The following skills were taught to all students: addition within single digits (0-9), addition within double digits (10-99), subtraction within single digits, subtraction within double digits, multiplication using groups, multiplication using arrays, division, fractions, patterns, measurement. These subjects were considered the basics of mathematics for elementary students, and the use of MMK in the experimental groups was helpful because that tool depends on the introduction of concretes, or Bruner's initial representational stage, in learning the concepts.

The students were divided into three groups at some times while at other times they were asked to work individually, to ensure skill retention and proficiency, by giving them exercises related to the previous topics and guiding them to use the LEGO tools in their application. The group work also helped to develop the spirit of social collaboration. It was noted that the students enjoyed learning with the LEGO tools, and that they increased their motivation. In fact, at the end of each session they would start asking about the next lesson, and asking that the lesson be a daily occurrence so they can play and learn at the same time.

Mathematics Achievement Test: to attain the aims of the study, a mathematics achievement test was developed to measure student achievement. The test consisted of mathematics skills (counting, addition, subtraction, multiplication, division, ordering, problem solving), and had 30 paragraphs. The face validity for this test was verified and the Cronbach's Alpha (α) was also verified, as it had a value of (0.87).

Data Analysis Methods: to answer the questions of the study, the researcher used the analysis methods of arithmetic means, standard deviation, Analysis of Covariance (MANCOVA), and Least Significant Difference (LSD).

Procedure:

This study took the following steps, and in the following order:

- Accessing the theoretical literature on the use of modern strategies for teaching mathematics, and the specific successful methods employed in teaching mathematics, with a particular focus on MMK and similar tools.
- Training the teachers on MMK using the training manual.
- Analysis of the unit content of study to identify concepts, principles, skills, problem solving, and to create the analysis validity.
- Preparing the achievement tests, presented for judgments and necessary editing, and applying resultant test on a survey sample to determine validity and reliability.
- Choosing the sample of the study in a deliberate manner, then randomly dividing it into two groups, one a control and the other experimental.
- Verifying the equivalence between both groups in terms of variables, then classifying the students according their previous test results into three types: low, middle, and high achievement.
- Teacher training on the parameter-based process of teaching students of the experimental group on the use of MMK, and display various examples of educational situations where the teacher can use MMK.
- Teaching the learning modules of the second grade mathematics book to the students of the experimental group with the help of MMK, with the support of the manual, while teaching the control group using the traditional instruction method.

- Administer the Mathematics Achievement Test to all the experimental and control groups' students, to get post-achievement scores.
- Analysis of the study results.
- Providing suggestions and recommendations.

Variables of the study:

Independent variable: The teaching strategies, of which there are two: the use of the MMK LEGO kit (experimental group), and the use of the traditional strategy without LEGO kit (control group).

Dependent variables: Mathematics Achievement Test (continuous variable).

Results

The aim of this study was to investigate the effectiveness of using a teaching strategy based on LEGO Education, the MoreToMath kit, in improving the post-achievement scores of students in Amman elementary schools. To answer the study questions, the arithmetic means and standard deviations of the experimental and control groups were extracted for each sub-group based on the level of students' previous achievement, as shown in Table 1.

Table 1. The Arithmetic Means and Standard Deviations of Student Scores for the Experimental and Control Groups for Each Level of Previous Achievement

Group	Level	Mean	Std. Deviation	N
Experimental	Low	64.65	7.645	20
	Middle	72.30	8.461	20
	High	83.35	12.106	20
	Total	73.43	12.206	60
Control	Low	58.70	8.909	20
	Middle	65.90	8.516	20
	High	79.25	9.049	20
	Total	67.95	12.206	60

It can be noted from Table 1 that the arithmetic mean of the students' scores in the experimental group, 73.43, is higher than the arithmetic mean of the control group, 67.95, which is an increase of 5.48. When looking at the individual sub-groups, based on the three pre-achievement levels of high, middle, and low, it can be noted that the experimental group increased by 4.1, 6.4, 5.95, consequently.

The following analysis was done to specifically answer the first question of the study, which is:

What is the effect of using the MoreToMath kit of LEGO Education on the achievement scores of elementary students in mathematics?

The multivariate analysis of covariance analysis (MANCOVA) was used to detect the significance of differences between the experimental and control groups in post-achievement, as shown in Table 2.

Table 2. MANCOVA of the Mean Differences between the Mean Scores of the Experimental and Control Group Students in Post-Achievement

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Pre-achievement group	1116.580	1	1116.580	14.705	0.000	0.115
Level of student group * level of student	683.957	1	683.957	9.007	0.003	0.074
Error	665.990	2	332.995	4.385	0.015	0.072
Corrected Total	157.049	2	78.525	1.034	0.359	0.018
	8580.470	113	75.933			
	18483.592	119				

It can be seen in Table 2 that there is a statistically significant difference ($\alpha \leq 0.05$) between the arithmetic means of the experimental and control group of students, in favor of the experimental group, with a value of ($f= 9.007, \alpha = 0.003$).

The next analysis was done to specifically answer the second question, which is:

What is the effect of the pre-achievement levels of elementary students in mathematics on their consequent achievement in mathematics?

Here, the previous MANCOVA was also used to detect the significance of differences between the three levels of pre-achievement on the post-achievement groups. As shown in Table 2, there is a statistically significant difference ($\alpha \leq 0.05$) between the arithmetic means of the three levels and the value of f reached ($f = 4.385$, $\alpha = 0.015$). In order to determine the preference in the three levels (low, middle, and high), a Least Significant Difference (LSD) test was used, the results of which are seen in Table 3.

Table 3. Least Significant Difference (LSD) Between Pre-Achievement Groups (Low, Middle, High) On Post-Achievement

Level (1)	Level (2)	Mean Differences	Sig.
High	Low	9.495*	0.005
	Middle	4.968	0.070
Middle	Low	4.527*	0.032
	High	-4.968	0.070
Low	Middle	-4.527*	0.032
	High	-9.495*	0.005

* The mean difference is significant at the 0.05 level.

It can be noted in Table 3 that there are significant differences between the high and low groups, and between the middle and low groups. However, the differences are not significant between high and middle.

A final analysis was done to specifically answer the third question, which is:

Is there any interaction between the used educational strategy and previous achievement levels of students on post-achievement of elementary students in mathematics?

Once again, the researcher refers to the MANCOVA in Table 2, which was used to detect the significance of interaction between groups (experimental, control) and the levels of pre-achievement (low, middle, high) on the post-achievement scores of groups. It indicated that there is no statistically significant interaction between which strategy is used, in the experimental and control groups, and the pre-achievement levels on post-achievement, with f ($f = 1.034$, 0.359). The graph in Figure 1 also shows that there is no significant interaction, although it shows that the experimental group is favored for the three levels (low, middle, high).

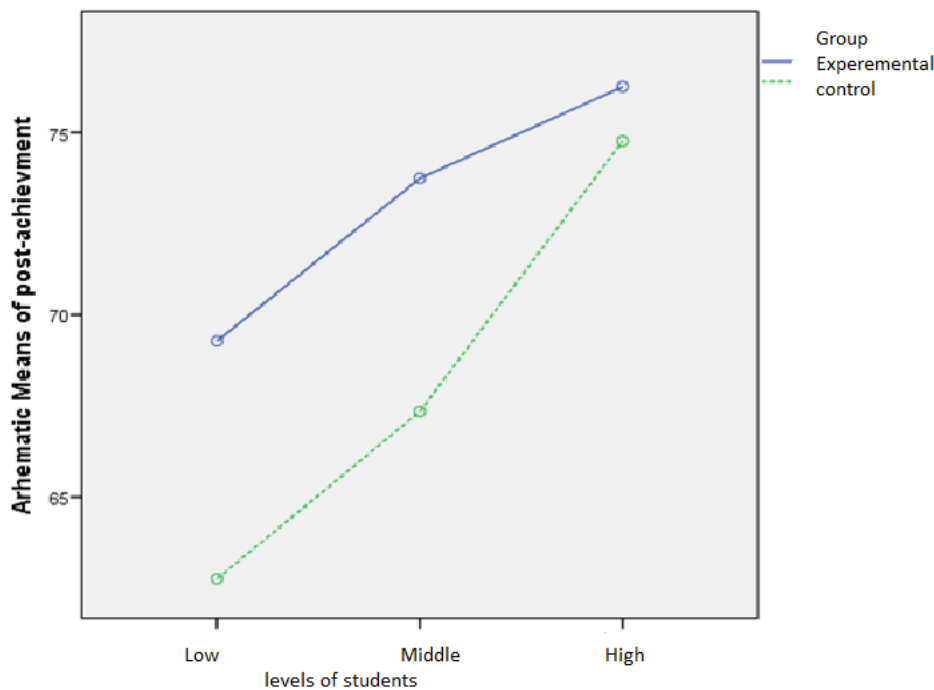


Figure 1. The Interaction between Group and Mathematics Student Levels

Conclusion and Discussion

The results of the study show that LEGO Education tools such as the MoreToMath kit (MMK) have a significant positive impact when used in elementary school mathematics teaching, and for all levels of students' previous achievement. The results also show that there is no interaction between the use of these tools and the students' previous achievement levels, and they show that post-achievement scores have generally improved over previous scores.

LEGO Education's MMK has many benefits, stemming from the hands-on nature of the kit. The students seem to enjoy playing and learning with it and, as the researcher observed through the teaching, all students were more engaged with classroom tasks. The students' motivation to learn mathematics had increased, and the kit supported the Bruner's theory sequencing of concepts for learning of mathematics: concrete then pictorial then abstract. Because of this, knowledge retention potential is high, and the students have acquired many studying habits like exploring and searching for solutions themselves. The MMK develops creativity and critical thinking in the process of learning mathematics concepts and facts.

LEGO is generally a tool that is useful in helping students work collaboratively, and with which teachers may better develop students' necessary skills for communication, collaboration, problem solving, and creativity. International standards for teaching and learning mathematics emphasize the need to use technology in teaching, and the importance of proper transmission and retention of learning.

This study's findings are consistent with those of previous studies on this matter, such as that of Polianskaya (2018) that suggests the importance of using tools such as those offered by LEGO Education in teaching mathematics; and the study by Herro and Quigly (2016), which exhibited the positive impact of an integrated strategy on teaching basic mathematics skills, and of using Bruner's stages in teaching mathematics sequentially— from concrete, to pictorial, then abstract.

Also the study of Mqawass (2018) pointed to factors that influence the acceptance of learning modern technology such as robotics in education, young students accepted the learning of modern technology more than adults and males more than females.

Recommendation

The researcher recommends using such LEGO Education tools as the MoreToMath kit for teaching mathematics, especially in the early, elementary school stages where the learners are not older than nine years of age. According to Piaget, learners at this stage have not yet reached the level of abstraction. Therefore, it is necessary to indulge their needs and present directly to their senses, and to teach mathematical skills in a sophisticated and interesting manner; and using appropriate tools that grab their attention while serving their educational needs.

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