Research Article

Effect of LEGO-Based Curriculum on Better Understanding of Mathematical Concepts among First-Grade Students

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Abstract: The overall objective of this study was to evaluate the use of LEGO-based curriculum on first grade students' understanding of mathematical concepts. The study population consisted of all first grade students in Tehran. Performances LEGO-based curriculum the school complies with its peers based on age, sex, fees received, the area and educational facilities. In this study, the sampling method, and targeted schools that agreed the project was done. A total of 30 first- grade students (15 males, 15 female) as students enjoyed the LEGO -based instruction and 30 students without the benefit of a LEGO -based implementation as control group randomly selected. To collect data in this study has been made by researchers from the Czech list. In this Czech lists several questions to gauge respondents' demographic information and to assess the hypothesis in which five closed-ended questions were used for assessing each components and the answers were set on a 5-point Likert scale. The results showed that the use of LEGO -based curriculum to better understanding the concepts of horizontal and vertical lines of symmetry, numerical and geometrical patterns in first-grade pupils in Tehran's influence. However, the results showed that the use of LEGO -based curriculum to better understanding the implications of the concept of ten categories has no effect.

Keywords: teaching math, LEGO-based curriculum, first grade, Understanding of Mathematical Concepts

1. Introduction

Nowadays, the advancements in the field of science and technology greatly influence our lifestyles, and cause changes in every aspect of them. These developments also affect the ways of teaching and learning. As a result, technological innovations reveal a new generation of education tools designed to help students to learn in a non-traditional way (Wood, 2008).

Play-based learning as one of the efficient pedagogy tools provides this opportunity to students to engage in purposeful activities that will allow for the simulation of such experiences they are likely to encounter and help scaffold the learning (Wood, 2008).

As children are naturally curious so they explore these concepts as they interact with their environment, as a result not only does Play allow the children to show their feeling, emotions and ideas but also it actively facilitates learning relevant processes such as rehearsing, practicing, repeating, imitating, exploring, discovering, revising, extending, combining, transforming, testing (Hughes, 1991).

Regard the importance of playing in children's life many scientists studied on play in early childhood education and noticed play is essential for learning and development (Wood & Attfield, 2005) which each of the pioneer's views different descriptions of play, meaning diverse theoretical perspectives and usages of it in learning and training. (Hughes, 1991).

Utilizing Play-based learning in student's curriculum is the bedrock of teaching students, many facilitators employ play in mathematic lessons for making the subject enjoyable. Players know that they are playing and that there is certain suspension of the constraints of the "real" world in which failing and succeeding have high stakes and meaning (Shechtman & Knudsen, 2009). So mathematical plays open up this opportunity not only for students but also for teachers to flourish their goals in an impressive way.

Griffiths (1994) noted that; if we want children to become successful mathematicians, we need to demonstrate to them that math is useful, and that it can be a sociable and cooperative activity, as well as a quiet and individual one so young children explore math when they play and build towers with blocks. In building, they sort the blocks by size and color, notice spatial relationships, and develop reasoning skills as they learn which shapes can be placed on top of one another, which ones will topple the tower they have built, and how to combine shapes to create familiar objects. So

they can boost a broad range of basic concepts such as counting (1, 2, 3); quantity (more, fewer); shapes (circles, squares, triangles); spatial relations (over, under); measurement (tall, short; bigger, smaller); and patterns (red, blue, red, blue) (Sarama and Clements, 2009; National Research Council, 2009).

Furthermore, Mathematic plays as a warm-up activity or reward (Bragg, 2006) are able to encourage children to improve logical thinking skills and to work on procedural knowledge such as addition, subtraction, multiplication and division facts count or compare objects as they play, and explore patterns and shapes (Seo & Ginsburg, 2004).

Ernest (1986) noted the success of all mathematics teaching depends to a large extent on the active involvement of the learner. Children learn mathematics by doing and by making the concepts and skills of mathematics their own. Playing games demands involvement. Children cannot play games passively; they must be actively involved, the more so if they want to become successful.

One of the active game-playing teaching method is LEGO -based curriculum which is never repetitive and boring and can make different and new shapes with LEGO pieces because they are assembled and shaped easily and are interesting for children who can make new things every day and enjoy them (Torkaman and Moghadam, 2007). LEGO classes allow students to show their abilities to perform the knowledge by simultaneous coordination of brain and hand.

2. Theoretical bases

According to Mac Kasker (2014) who considers constructivism and mind-hand relationship as learning theories that support LEGO education classes, LEGO -based curriculum has two different theoretical bases.

2.1. Constructivism theory

Theoretical foundations of constructivism are affected by wigi theory (1980) and cognition theory by Leo (1988). Constructivism by Piaget was individual constructivism. On the other hand, the knowledge comes from students' interactions with their environment (Hussain et al, 2006). Also Creating knowledge is done through the process of creating a mental-physical model of some aspects of the Vygotsky's Dialectical Constructivism Theory; accordingly, the LEGO-based curriculum allows the individuals to not only start positive interactions with one another, but also gives them the ability of continuing the interaction. It also includes a number of skills such as relationship formation, problem-solving, decision-making, and self-management (Seven and Yodas, 2007; and Van squik, 2008, cited by Aydogan and colleagues, 2009) which is considered as a method for supporting the students to guiding them, and also paving the way for obtaining their potential development level.

The process of modeling during teaching helps people and groups to concentrate on their thoughts and have a creative communication between ideas, experiences, and people (Nerantzi and Despard, 2014). Thinking and modeling are the same aspects of a process and different modeling by LEGO can help students to express and reflect their thoughts and knowledge. Creating knowledge by modeling process (mental/physical) is an aspect of Piaget's constructivism theory (Gauntlet, 2011).

Furthermore, this curriculum emphasizes on the effective role of objective things on the complicated process of creating knowledge (Papert, 1993). The importance of this method is that it enables children to solve challenges and group problems by thinking objectively, moving towards innovation, and changing their point of view about responsiveness and group responsibility. Furthermore, it increases their ability to cooperate in the group and gain knowledge about its challenges (Bulmer and Smith, 2011).

2.2. hand-made models

The basic idea of LEGO education classes is to make three dimensional hand-made models, based on knowledge, ideas, and feelings to create a new way of free and creative thinking (Gauntlett, 2011). More than 50 years ago neuroscientists found that a large part of the brain controls human's hands (Penfield and Rasmussen, 1950). With regards to mind-hand relationship theory and its effect on human's learning, it can be claimed that the main essence of LEGO is creating a complicated interaction between hand and mind (Kristiansen and Hansen, 2009).

The deep link between the brain and hand does not mean that hand has a valuable role for gathering information or manipulating things. It means that brain and hand work together to think and create meaning (Gauntlett, 2011). Therefore, we can state that students' interaction with educational tools in addition to the knowledge leads to creativity and social skills' development.

Lim-Teo (1991) classified such games as: "games for drill and practice; games for concept reinforcement; games which lead to concept formation; games which lead to mathematical investigations; games which apply mathematical knowledge; games for fun" (1991, p. 48). The games in this study were selected to investigate their potential to lead to concept formation through expanding children's understanding of multiplication and division of decimal numbers.

It is true that, according to the importance of offering modern educational methods for the purpose of improving mathematical skills among students, numerous studies have been conducted on this topic such as the research conducted by Gold and colleagues (2020) and Smith and Chao (2018), but no research was found on the effectiveness of LEGO-based curriculum on better understanding of mathematical concepts and employing them in daily life among students. Thus, according to the existing gap, it is important to research whether LEGO education technology really is useful in teaching mathematical ideas. The research question used as a basis for this paper is whether games result in better learning of mathematics than do non-game activities.

3. Method

The present study was an action research which was conducted by semi-experimental method with a pretest-posttest with control group design.

3.1. Participants

The research population included all the first-grade students of Tehran, Iran. The statistical sample included 60 seven year-old students (30 boys and 30 girls) studying in the first grade in the 5th district of Tehran. In the current design, 4 classes with 15 students from 4 different primary schools were selected; Such that, by available sampling method, 30 first-grade students (15 girls and 15 boys) were selected as the LEGO-based training (experiment) group and 30 students were selected as the control group (without LEGO-based training). For the sake of controlling the intervening variables, the experiment and control groups were matched based on age, gender, school tuition, district, and the provided educational facilities, and the sample subjects were randomly assigned into both groups

3.2. Instruments

3.2.1. The researcher-made checklist

For gathering the data, a researcher-made checklist was used. This checklist consisted of 2 parts; The first part includes questions for assessing the demographic status of the respondents and the second part includes 9 components with educational topics in mathematics (Symmetrical shapes, Symmetrical shapes and horizontal and vertical line of symmetry, Numerical and geometric pattern, Time, Ten-groups, even and odd numbers, Ordinal numbers, Place value of numbers, Comparing basic concepts) in which 5 closed-ended questions were used for assessing each components and the answers were set on a 5-point Likert scale; Without a correct answer for any of the 5 questions, the subject would obtain 1 score and with providing correct answers for all 5 questions, the resulting score would be

3.2.2. Validity

In order to make sure of the measurement tool's validity, content validity method was used in the present research and the above checklist, after development, was delivered to 4 experts in mathematics course and 2 psychologists specialized in child psychology for evaluation.

3.2.3. Reliability

The retest method was used to test the reliability of the checklist; Such that, first 10 first-grade students completed the checklist. After ten days, the checklist was delivered to the same students to complete it again. The obtained Cronbach's alpha coefficient equaled 0.85 which shows a suitable reliability for the questionnaire. Because first-grade students are not able to read, the teacher of each class helped the students complete the questionnaire as an individual operational report.

3.2.4. The LEGO-based curriculum:

The present curriculum consists of a workbook for students and teachers and a pack of LEGO pieces. The main idea of the LEGO-based curriculum is close to More to Math educational packages and educational LEGO with HUSO (Humanities and Social Skills) level which has been designed by experts of this course according to the latest changes in concepts of classroom in the first grade in Iran.

These lesson plans are designed in a way that students learn various mathematics concepts indirectly and unconsciously by active participation in interesting and varied tasks in the book which are completed by using LEGOs. In addition to teaching these concepts, this book has presented problem-solving as its most important concern and tries

to improve this skill in students. By providing a detailed teacher's guide in the end of the book, it has been tried to answer all the common ambiguities and questions related to the book.

3.2.5. Educational topic of the LEGO-based method:

1. Counting and recognizing numbers
2. Pattern finding
3. Teaching shapes and geometrical concepts
4. Symmetry finding
5. Addition and subtraction
6. Approximation, scale and using tools
7. Clock training
8. Teaching comparison and arranging numbers from small to large and vice versa
9. Improving skill topics including auditory, speaking, manipulation, focus, attention and group work skills
10. Problem solving

3.2.6. Procedures

First, a number of questions were answered by the experiment and control groups as the mathematics test including 9 components or course topics with 5 questions for assessing each component (the researcher-made checklist). Then, the experiment group participated in a 12-week LEGO-based curriculum in the mathematics class, and the control group solely participated in the standard mathematics classes which were taught based on the protocol of the Department of Education and in which education is teacher-based, without direct participation and activities of students, and without using educational tools. Also, with the parents' consent, the control group students were not allowed to use any educational videos or any other educational tools, and to get help from parents in doing their mathematics homework. Afterwards, the learning level of both groups was assessed by the researcher-made checklist-the matched form which includes 9 components and 5 questions for each component. Finally, the results of both groups were compared.

In the present research, descriptive statistics method (frequency distribution, percentage, mean) and inferential statistics method with independent T-test were used for assessing the mean of both experiment and control groups. The data were analyzed by SPSSv18 software.

4. Findings

The results for all measures are presented in Table 1Table 1.

Table 4-1: Independent Samples Test

Variable Symmetrical shape	**Group LEGO-based curriculum**	**N** 30	**Average of mathematic progress**	**30 years or more**	**Average of mathematic progress**	**number**	**total**
Symmetrical shapes, horizontal and vertical line of symmetry	No LEGO-curriculum	30	414.67	44	422.02	60	168
	LEGO-based curriculum	30	396.90	91	413.49	108	
Numerical and geometric pattern	No LEGO-curriculum	30	385.18	59	429.97	76	187
	LEGO-based curriculum	30	386.44	92	418.04	111	
Time	No LEGO-curriculum	30	378.40	81	424.86	92	209
	LEGO-based curriculum	30	389.09	89	431.91	117	
Ten-groups	No LEGO-curriculum	30	415.37	109	446.27	122	248
	LEGO-based curriculum	30	400.71	113	445.73	126	

The 30 participants who received the LEGO-based curriculum intervention (M = 152.47, SD = 28.23) compared to the 30 participants in the no LEGO-based curriculum group (M = 146.52, SD = 26.78) demonstrated significantly better scores in symmetrical shape, t (58) = 12.85, p = .0001.

There was a significant effect for curriculum, t (58) = 6.33, p = .0001, and LEGO-based curriculum group (M = 157.41, SD = 27.11) attaining higher scores than no-LEGO-based curriculum (M = 148.22, SD = 25.55) in Horizontal and vertical lines of symmetry.

This study found that participants in experimental group (M= 143.66, SD= 27.37) compared to control group (M= 132.91, SD= 25.45), had statistically significantly upper scores in Numerical and geometric pattern, t (58) =16.11, p=0.001).

Students who received the LEGO-based curriculum intervention (M = 142.13, SD = 26.82) compared participants in the no LEGO-based curriculum group (M = 140.58, SD = 24.12) did not show significantly better scores in time, t (58) = 4.17, p = .08.

There was no significant effect for the type of curriculum, t (58) = 1.12, p = .3, and LEGO-based curriculum group (M = 144.77, SD = 28.40) achieved higher scores than no-LEGO-based curriculum (M = 14.52, SD = 27.98) in ten-groups.

The results show that students in experimental group (M= 147.20, SD= 27.41) in comparison with participants in control group (M= 140.72, SD= 25.67) were significantly better (t (58) = 4.55, p= .0001) in Even and odd numbers.

There was a significant effect for the type of curriculum, t (58) = 10.62, p = .001, and LEGO-based curriculum group (M = 154.12, SD = 29.57) received higher scores than no-LEGO-based curriculum (M = 147.66, SD = 26.41) in ordinal numbers.

The results present that students in experimental group (M= 146.11, SD= 26.50) compared to control group (M= 141.53, SD= 25.67) were significantly better (t (58) = 8.95, p= .0001) in comparing basic numbers.

5. Discussion and Conclusion

The overall objective of this study was to evaluate the use of LEGO-based curriculum on better understanding of the concepts of symmetrical shapes, horizontal and vertical line of symmetry, numerical and geometrical pattern, time, even and odd numbers, ordinal numbers, place value of numbers and comparing basic concepts.

The results obtained from table 1 suggest that using a LEGO-based curriculum had a positive impact on first-grade students of Tehran which was consistent with the results obtained by Gold and colleagues (2020) and Smith and Chao (2018). In explaining this finding, two theories can be used.

Based on the constructivism theory, a class in which the teacher acts as a facilitator and provides an appropriate and happy setting for learning can be considered as a dynamic class; Such that students are encouraged to have an active participation in the classroom and, therefore, each one of the class members can, by enhancing their spirit of inquiry alongside their classmates, realize their potential developmental level.

it must be noted that Constructivism provides the best theoretic foundation for understanding of learning principles that govern learning in math LEGO-based curriculum classrooms because it emphasizes the importance of a learner-centered approach to learning, where a learner takes an active role rather than a passive role and crucial importance of the learning environment thus accentuating the potential of VR technology application.

Findings from this study generally support the hypothesis that Young children can cope with great difficulties in their mathematics learning. Teachers also can cope with great difficulties in their facilitation of children's learning. These difficulties can be solved if teachers build relationships with the children in the class and know what mathematics they know, how they know and how they can use it to solve realistic problems. Teacher can develop challenging and complex experiences for young children. They can help children to reach their potential in mathematics learning.

In addition, oldfield's characteristics are practical and constructive as a guide for selection of games in most situations. However, a characteristic that facilitates dialogue was determined as necessary as peer discussion is valuable

to provide immediate feedback to students during game playing, especially in the absence of teacher assistance (Booker, 1996).

Social engagement through discussion assists children in constructing knowledge that fits with the social milieu (Wood, 1995). Gough (1993) emphasized the social element when he defined a game as incorporating some of the following characteristics as a group playing and thinking activity that satisfies the following conditions: "It involves more than one "player"; players interact with each other what one player does in turn will affect in some way what the subsequent player or players can do in following turns; although there may be some degree of luck (such as a dice roll, or dealing of cards), there should be some room for a player to choose how to play" (p. 218).

Mathematical play contains long process. Holton et al. (2001) notes that during the mathematical play children use their current knowledge and mathematical play develops links between the current schemata while the play is occurring. Mathematical play reinforces the current knowledge and it assists future problem solving/mathematical activities. During the mathematical play activities, children come across different types of daily problems and they construct several solution ways for them spontaneously. Therefore, mathematical plays support the logical thinking and create powerful learning environments

In the LEGO-based teaching method, after the entrance of students into the class and their placement in dialogue circles, the facilitator first makes use of various tools and asks questions related to the lesson plan and then integrates the information and knowledge of students, then and in the next step, the students are faced with practical mathematical problems in their personal lives. Afterwards, each one of the students collaboratively and actively decides how they seek to solve the existing challenge by using LEGO pieces.

The notable point is that it is true that there is one single answer for mathematical problems, but in LEGO-based classes, there isn't just one predetermined way for reaching the answer or there isn't any obligation to follow a predetermined pattern for finding the answers and, therefore, the students step by step create their suggested solutions with LEGO pieces; So, education is done in a research setting which not only leads to an original, in-depth and permanent learning in students, but it also enhances the abilities of management, planning and self-control amongst them.

In addition, according to the mind and hand relationships approach in this method, the teacher him/herself must be knowledgeable about the objectives and how-to of the LEGO-based teaching method so that s/he would be able to explain them to the students. And unlike the passive and teacher-based methods, the LEGO-based method is active and student-based so that different abilities of each student, their dominant learning styles, and their learning speed are considered, and by turning their solutions and thoughts into LEGO structures they create with their hands, students can enact their ideas in a better way because, after the practical procedure of LEGO making, they gradually understand the reasons behind mathematical concepts which leads to enhanced self-confidence and logical thinking amongst them.

In this method, the teacher's tasks are: paying attention to the works of all the students and providing necessary guidance, making them interested in academic works and activities, getting to know the students and recognizing their abilities, and most importantly, guiding the students learning a new academic material through its different stages in a step by step way. The students' task is being active, apprenticeship and exploration according to the best of his/her abilities. The LEGO-based method is so interesting for students because this method teaches mathematics via the game rules and facilitates the understanding of this course for students.

6. Limitations

These results provide a foundation for future research to develop more precise measures to identify children at risk for mathematics difficulties, as well as incorporate mathematical language within preschool mathematics curricula, in order to prepare children for successful entry into formal schooling.

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