The Impact of Cognitive Training Program for Children (CTPC) to Development the Mathematical Conceptual and Achievement

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This study aimed to investigate the impact of the Cognitive Training Program of Children (CTPC) on development the of mathematical concepts and achievement in mathematics among third-grade students. The study sample consisted of (113) students distributed randomly into three groups: the first experimental group (39) students who taught through CTPC individually, the second experimental group (36) students who taught through CTPC in small groups, and the control group (38) taught in the traditional method. A mathematical conceptual development test, mathematical achievement test, and qualitative scoring rubric were prepared as instruments to collect the data. The results showed that there were statistically significant differences between the three groups, in favor of the two experimental groups, and statistically significant differences between the two experimental groups in favor of the second experimental group, which was trained on CTPC in small groups, compared to the first experimental group, which was trained on CTPC individually. The study recommended paying attention to CTPC, inviting teachers to use it in teaching mathematics, and providing guides for teachers to plan lessons using CTPC.

Keywords: Cognitive Training Program of Children (CTPC), mathematical conceptual, achievement

INTRODUCTION

Mathematics is an essential science for any individual, regardless of their culture, as it enables them to make their decisions easily, and it has an important role in the advancement of communities, as it works to solve many of the problems facing a society that seeks to be scientific and technical. Mathematics is one of the distinguished fields of science that contribute to other areas of knowledge and provides any sector that is linked to broad mathematical knowledge. Hence, providing young people with mathematical skills is a major requirement for life skills prepare. To provide young people with mathematical skills, it is necessary to develop teaching programs and strategies that match the required life skills, and devote a lot of literature and studies to this work to train teachers in these programs and motivate them to use these programs and teaching strategies that have proven their effectiveness.

Using effective teaching strategies and programs in mathematics with children that can stimulate their thinking and increase their achievement may help to form correct mathematical knowledge structures in the early stages of learning, as well as enhance the possibility of achieving learning goals and outcomes for

these stages. The goals of teaching mathematics are no longer limited to acquiring practical skills and remembering concepts and generalizations. They have gone beyond the goals of acquiring the language of mathematics, understanding those concepts and generalizations, increasing the ability to observe and analyze relationships, observing accuracy in information processing, teaching them logical thinking, approximation, guessing, and arithmetic estimation, discovering the applied aspect of mathematics in daily life, thinking about solving problems and gaining self-confidence (Arifj & Suleiman, 2005; Rasheed & Tashtoush, 2021).

Psychologists believe that the cognitive structure of children is the sum of the child's experiences resulting from his interaction with environmental, genetic, and biological factors, and through his growth and adaptation in the early stages of life. The development of an individual's cognitive structure is linked to the development of new cognitive units, processes, and cognitive functions that are reflected in them. As these functions become more complex, they indicate the development of the child's cognitive structures, because cognitive structures are one of the most important foundations of mathematics learning outcomes (Bugden et al., 2016).

At the end of the last century, a group of researchers tried to take advantage of neuroscience studies and the approach to information processing in presenting a teaching method called ***Cognitive Training Program for Children***, ***CTPC***, which includes the active participation of children in the classroom and extra-curricular learning. Teachers place their students in complex educational experiences and expose them to an environment rich in experiences (Winters, 2001).

CTPC is a simple model of planning, reflection, and problem-solving. But at a deeper level, cognitive training acts as the core of professional communities that respect the independence, encourage interdependence, and produce high achievement (Costa & Garmiston, 2009). CTPC focuses on developing their mathematical skills, in this context, several studies have shown promising results for the computerized CTPC with special needs such as Attention Deficit Hyperactivity Disorder by focusing on some aspects of knowledge, especially attention and memory with a general interest in other aspects of knowledge (Bikic et al., 2015).

Rosenberg-Lee and others believe that CTPC is a complex model of planning, reflection, and problem-solving in educational or training situations, a reflective, non-evaluative development model that emerged from a combination of psychological, cognitive, and social orientations. It focuses on growing the learner's cognitive development through their intellectual functions (Rosenberg-Lee et al., 2018). While (Costa & Garmston, 2009) believes that CTPC consists of a set of elements that can be practiced, tested over time, and integrated as an integral part of the learner's daily interactions, and become part of the trainer's identity as a facilitator of self-directed learning. Eventually, the values and beliefs of cognitive training become a life view. These elements are:

- **Skills:** Cognitive trainers are skilled at building and asking questions to operate and change thought. They use their non-evaluative responses to enhance and maintain trust and intellectual preoccupation, they use non-verbal behaviors to establish and maintain intimacy or good relationship, know their intentions, choose behaviors that are consistent with them, exclude unproductive patterns of listening, and responding, and research, modify their preferred methods, and making their way through several maps to guide their interactions.
- **Mental Maps:** Cognittrainersers' value self-directed learning, as they are happy to help others become more capable of self-management, self-inspection, and self-modification. They are always interested in promoting individual differences in methods, beliefs, and preferences in form or style, developmental, cultural, and gender levels.
- **Beliefs:** Cognitive trainers believe that all behaviors are determined by an individual's perceptions and that a change in perception and thinking is a prerequisite for changing behavior. They also believe that humans make sense of things by passing through experiences and that any individual can continue to develop their cognitive abilities throughout their lives.
- **Values and Commitments:** Cognitive trainers are committed to learning; they constantly resist self-satisfaction, share the humility and pride of saying that there is much to learn,

dedicate themselves to serving others, neutralizing their own needs, devote their energy to enhancing others' proficiency or good thinking, and dedicate their time and energy to make a difference to those around them by promoting interdependence.

The importance of CTPC is to change learners' thinking structure by training them to modify new thinking skills, other than the ones they used before, applying specific problem-solving strategies, then providing learners with the strategies they need to modify ideas, in addition to training them for self-initiative and overcoming motivational and passive problems through their involvement in treatment processes (Bugden et al., 2016; AL-Balushi, 2014).

CTPC is a combination of strategies, a way of thinking and working that requires the learner to think and reconsider his thinking and abilities to solve problems, and then reach the stage of self-assessment of thinking to reach different mental levels and move between them flexibly so that the learner becomes able to learn self-directed through self-management, self-monitoring, and self-modification (Rosenberg-Lee et al., 2018; Bugden et al., 2016).

CTPC activities for children aim to create a balance, harmonization, and participatory action in work between self and others, between reality and reflection of reality, between self-growth and event growth, and to build and maintain self-confidence, relationship with others, thinking, and working atmosphere. They aim to reflect student thinking and call for mental thinking strategies that enhance information stored in thinking, in the sense of employing thinking in action, looking for ambiguity in issues, events, and assumptions, forming new principles in solving, maintaining cognitive growth, and creating confidence by helping others develop knowledge. CTPC activities also aim to enable the student to make decisions according to his own experiences between self-development and others' participation, to be able to communicate and integrate with another person to obtain help in self-orientation, and also to be able to use previous knowledge of information and concepts stored in memory, using the skill of induction as a guide towards the right solution, improving the solution, and finally being able to search and investigate information and data that confirms the solution, whether from reality or others (Costa & Garmston, 2009; Bugden et al., 2016; Rosenberg-Lee et al., 2018).

We conclude from the above that the teaching and learning process should be based on the activity and effectiveness of the learner himself, not the teacher's activity alone, and the transformation from the teacher-based teaching and learning process to the student-based learning process. This requires various educational activities and intensive efforts by the learner to stimulate his potential and motivate him to learn. It also requires the teacher to create the appropriate conditions for these processes and activities (Bugden et al., 2016; Bikic et al., 2015).

Understanding is one of the main goals of learning and teaching mathematics. Each child has a unique perspective on how they understand mathematical concepts, and their nature, and relate to ideas. Understanding varies from child to child, (Dreyfus, 1991) believes that understanding is a process that occurs in the brain quickly and depends on a wide range of learning activities. Therefore, it is difficult to acquire mathematical concept within the brain. (Hiebert & Carpenter, 1992) describes understanding as how information is represented, and built and connections are made between them, and that the degree of understanding depends on the number of connections between ideas, representations, and procedures. (Barmby, et al., 2009) considers that understanding develops the connections between ideas, facts, and processes, and forming a network of these links provides a structure that illustrates new information by linking similarities, differences, overall relationships, and transition relationships between various models. (Tall et al., 1981) indicates that if the child has a weak image of the concept, it will lead to misunderstanding. While (Balka et al., 2015; Fannakhosrow et al., 2022) indicate that a good construction of conceptual understanding is to review the principle of learning, which states that children should learn mathematics with comprehension by linking new knowledge to previous knowledge and experiences.

Understanding children's mathematical concepts are one of the pillars of mathematical competence that makes parts of mathematical knowledge including facts, generalizations, principles, laws, and rules linked to each other by close connections. Including producing examples and non-examples of mathematical concepts, using shapes and drawings to express them, recognizing the connection and complementarity of

mathematical concepts, identifying principles, laws, and rules related to mathematical concepts, and interpreting the relationship between them (Tall et al., 1981; Hiebert & Carpenter, 1992).

For children to gain a true conceptual understanding, they must have direct experiences. Therefore, children need many experiences related to a variety of topics that enable them to actively explore (English, 2012), as well as their needs to learn about relationships, solve problems, compare their observations and discoveries, learn specific skills, and write down their discoveries using symbols. Attention to developing conceptual understanding of children's mathematical concepts is therefore expected to contribute to strengthening children's mathematical learning to reach understanding learning in mathematics since learning concepts is the basis for any knowledge. Therefore, a child cannot perform a certain logical skill unless he has a mathematical concept that he is fully aware of (Barmby et al., 2009; Balka et al., 2015).

The results of international studies in math and science learning, such as the *Program of International Student Assessment, PISA,* and the Trends in *International Mathematics and Science Study, TIMSS*, show that there has been a significant decrease in student achievement levels in math and various mathematical skills. The USA has recorded a significant decline in its student results in international studies that measure achievement and acquisition of science and math skills (Higgins et al., 2016). Jordan recorded a significant decrease in its students' results compared with the international results of the participating countries, which would sound alarm bells for other countries that in turn are recording a clear decrease in knowledge and basic mathematical skills. The educational reality indicates a decline in these skills among Jordanian students, as reflected in the results of several international studies in which Jordanian students participated.

In the results of the fifth cycle of *PISA*, in which Jordan participated (2012), the overall average in mathematics for Jordanian students was (386) points, and the overall average of (65) participating countries was (494) points, ranking (57) at the international level. In the sixth round (2015), the overall average dropped to (380) points, and the overall average of all (72) participating countries was (490) points and ranked (67) internationally. In the seventh round (2018), the overall average increased to (400) points, and the overall average of all (79) participating countries (459) points and an international ranking of (65). The results show Jordan's progress in the Arab and global regions, even though Jordan's overall average remains much lower than the overall average of the countries participating in the study (The Ministry of Education, 2018).

In 2007, the average performance of *TIMSS* of Jordanian students in mathematics was (427) points, while the overall average of all (50) participating countries was (451) points, making the average performance of Jordanian students statistically below the international average, ranking (31) at the international level. The average performance of students in (2011) dropped to (406) points, and dropped again in (2015), to (386) points (National Centre for Human Resources Development, 2017).

Among the factors that affect academic achievement are factors related to students, such as health and physical condition, which is affected by a disease that has affected the child and caused him to suffer negative effects and has led to school delays, a decrease in academic achievement, social and family factors. The family may be the direct cause of the child's low achievement, possibly due to its constant urgency and pressure to raise the level of academic achievement without considering the child's mental abilities and tendencies, which leads to a counterproductive, as well as the material conditions experienced by the family that directly affect student achievement. As for the factors related to the teacher and the method of teaching, the teacher has an essential and direct role in the level of his student's achievement, through his characteristics, his ability to diversify modern teaching strategies according to the subject he wants to teach, the way he deals with students, his consideration of individual differences, and his departure from prejudice (Rasheed & Tashtoush, 2021; AL-Bouhi et al., 2018; Tashtoush et al., 2023).

Problem Statement

The current study problem is represented in the poor achievement of students in mathematics, the problem that the students suffer from locally and internationally, which was confirmed by the results of the national test for quality control of education conducted by the examinations department at the Ministry of Education, which showed the students' poor level in mathematics. Internationally, Jordan, like most countries in the world, complains of its students' poor level in mathematics, as indicated by the results of

PISA and *TIMSS* tests, which Jordan students participated in performing, that there is a clear weakness among students in mathematical achievement after they confirmed on its importance as a way to deal with problem-solving and learning in the classroom. Through the field observation of researchers while working as math faculty members for different educational levels, some of whom supervised the field training of students, pre-service math teachers in the educational field and others participated in some international and local tests, they noticed a lack of acquisition and development of mathematical concepts in general among students, a low level of real understanding of mathematical concepts, and the concept of multiplication for the third-grade level in particular. This shortcoming results from students' failure to link their new experiences to previous experiences, failure to study mathematical concepts correctly, and their weak ability to link multiple representations of mathematical concepts. Specifically, the problem of the current study was trying to answer the following main question: **What is the impact of CTPC on the development of mathematical concepts and achievement?** The following two questions came out of it:

1. Are the levels of third-grade students on the mathematical concept development test differ depending on the teaching method (using CTPC for individuals, using the CTPC for small groups, and traditional methods)?
2. Does the performance of third-grade students on the mathematical achievement test differ depending on the teaching method (using CTPC for individuals, using the CTPC for small groups, and traditional methods)?

Study Importance

This study derives its importance from the importance of the field in which it examines, which is to develop and acquire an understanding of mathematical concepts and improve their levels of understanding, to improve students' achievement in mathematics. The theoretical importance of this study is represented in its presentation of the idea of building a training program that is expected to have a positive impact on developing the conceptual understanding of mathematical concepts and improving the level of achievement of children in a school environment, which may contribute to enriching the theoretical and applied aspects of studies in this direction of research. The current study is a new addition in its attempt to investigate the impact of the cognitive training program for children in developing conceptual understanding levels in mathematics and improving the level of mathematical achievement. The practical importance of this study is to help early childhood teachers advance learning and teaching and to push the educational process towards development, diversity, and modernization in mathematics teaching methods, the instruments of this study may be used to conduct further studies in this regard and expand them for different communities and variables.

Procedural Definitions

- **Cognitive Training Program for Children (CTPC):** A set of educational procedures used in teaching the multiplication module to two sections of third-grade students, individually for one division, and as small groups for the other division. These procedures consist of preparing for the lesson by asking questions, and solving the previous homework, picture, ,game or competition to reveal previous learning for students to use in new learning.
- **Conceptual Understanding**: Knowledge that includes understanding mathematical terms and symbols, the different relationships and ideas that are linked to each other that lead to a deep understanding of the mathematical concept.
- **Mathematical Achievement:** The score obtained by the student on the achievement test preparation for study purposes.

Limitations

- **Human Limits:** The current study is limited to a sample of third-grade students.
- **Temporal Limits:** This study was applied during the first semester of the academic year 2022/2023.

- **Spatial Limits:** This study is limited to students of public schools affiliated with Jordan.
- **Objective Limits:** This study emphasizes the importance of using a CTPC to develop conceptual understanding and improve the student's achievement in math.
- This study is determined by its instruments and its psychometric characteristics, which are acceptable for scientific research purposes that were prepared to achieve the objectives of the study.

LITERATURE REVIEW

Through research and investigation in previous studies of the CTPC, no studies have been found that have examined the impact or effectiveness of the cognitive training program for children in developing the levels of conceptual understanding in mathematics. However, it was found that some studies have been conducted in this field to reveal the impact of the cognitive training program on some variables. In this field, (Montague, et al., 2011) conducted a study aimed at identifying the impact of cognitive strategies on solving mathematical problems for students with learning disabilities in middle school in the USA. The study sample contained two groups: An experimental group of (319) students who received a remedial program based on cognitive strategies, and a control group of (460) students. The results showed an improvement in solving mathematical problems among the students of the experimental group compared to the control group that was exposed to the usual method of teaching mathematics.

A study by (Swanson, 2014) sought to investigate the effect of a CTPC in solving word problems and working memory capacity by measuring basic math skills. The study sample consisted of (146) third-grade children from public schools in the USA, the children were divided into children with difficulties in mathematics and children without difficulties in mathematics. The 25^{th} percentile grades were determined in math achievement tests to make the difference between children with mathematics difficulties and children without difficulties. This procedure separated children into (58) children with difficulties in math, and (88) children without difficulties. The program was applied in small groups and the study included three tests: Intelligence, reading, and math. The results of the study indicated that the CTPC facilitated the solution of word problems among children with a relatively high level of working memory capacity, as statistical analyses indicated that there were statistically significant differences in post-tests in favor of children with a relatively larger working memory capacity.

In a study conducted (Shman-East, 2015) aimed to identify the effectiveness of electronic cognitive training in enhancing memory work and achievement in mathematics among primary school students with low achievement in math, the study used a semi-experimental approach. The study sample consisted of (30) fifth-grade students in the USA, including (15) students as a control group and (15) students as an experimental group. The results showed that the experimental group studied with electronic cognitive training outperformed the group that studied traditionally in promoting Memory, and the achievement of the experimental group students was better than the students of the control group.

In a study conducted by (Swanson, et al., 2015) to investigate the role of cognitive strategies and working memory in developing verbal problem-solving in math among children with math learning difficulties, the study sample consisted of (100) ordinary children and (92) children with learning disabilities from public schools in the USA, in which visual and nonvisual cognitive strategies were used. The results showed that the effect of visual and nonvisual cognitive strategies was statistically significant for both samples of children. It also showed that visual cognitive strategies had a higher impact on children with learning difficulties.

The study of (Carpenter, et al., 2016) aimed to identify the effect of CTPC on memory, visual and auditory processing, processing speed, thinking, attention, and general mental abilities in solving mathematical problems among children aged from (8 to 14) years in primary schools in the USA. Participants were randomly assigned to an experimental group of (20) children who were subjected to a CTPC, and (19) children as a control group studied in the usual way. The results showed statistically significant differences between the two groups in favor of the experimental group on all skills except for concentration skills.

(Wexler, et al., 2016) the study aimed to identify the impact of both cognitive preparation and training on immediate and delayed achievement in math and reading among children in the USA. The study sample consisted of (583) children who underwent three brain training sessions for (20) minutes for four months. Children were subjected to brain training games for five minutes before entering mathematics and reading environments, and the results indicated improved brain functioning and higher student achievement, both immediate and postponed.

As for (Jedlicka, 2017) study, it aimed to identify the role of a cognitive training strategy for children as a therapeutic intervention for poor cognitive skills, achievements, and academic weakness among students aged from (5 to18) years in America through parents. It also aimed to reduce complaints by parents regarding academic weakness in their children's reading and mathematics skills. A codified measure of parental appreciation was applied to a sample of parents consisting of three groups: The first group of (67) parents was exposed to the cognitive training program in mathematics, the second group of (53) parents was exposed to the cognitive training program in reading, and the third group as a control group of (58) parents were exposed to the traditional program. The results indicated that there were statistically significant differences between the two experimental groups and the control group on all academic difficulties measures on the parental rating scale and in favor of the two experimental groups in terms of a decrease in the level of academic difficulties in reading and mathematics, while the level of academic difficulty of the control group students remained high. In a study conducted by (Rosenberg-Lee, et al., 2018) aimed to investigate the impact of cognitive training on improving cognitive functions, the study sample consisted of (19) children who underwent eight weeks of cognitive training at Stanford in the USA. The study showed that there were no changes in the cognitive functions of the short-term cognitive training program.

METHODOLOGY

The current study adopted the semi-experimental approach, which included three groups: The first experimental group was applied to the CTPC individually; the second experimental group was applied to the CTPC in small groups (4) students per group, and the control group, which was taught in the traditional methods.

Participants

The study sample consisted of third-grade students in one of the schools in Jordan. This school was selected in an accessible manner. Coordination was made with the school principal and the cooperating teacher, after confirming the presence of three third-grade divisions. The study sample consisted of (113) students divided into three groups: The first experimental group has (39) students, the second experimental group has (36) students and the control group has (38) students.

Instruments

Test of Conceptual Understanding

After reviewing the theoretical and research literature (Barmby et al., 2009; Fannakhosrow et al., 2022; Balka et al., 2015; Tashtoush et al. 2020 b), a test was prepared to develop the levels of conceptual understanding, which consists of five tasks, the student must achieve the solution by formulating the answer using one of the four methods covered during teaching the multiplication unit, which is: (Repeated addition, Columns, Geometric Models, and Analysis of two numbers). The formula of the tasks considered the comprehensiveness of the module's topics, their clarity, and suitability for the age level of the students. A specification table was prepared for the test and corrected through a qualitative correction framework prepared for this purpose. To verify the validity of the tool, it was presented to a group of arbitrators from specialized university professors, who were asked to give their opinions and comments on the test tasks and their suitability for the objectives they were set for, as well as the soundness of the language formulation and its affiliation to the fields of study. Based on the arbitrator's opinions, amendments were made until the test was finalized. To identify the effectiveness of the test tasks as an indicator of the internal honesty of the test, the difficulty and discrimination factors of the tasks were calculated after applying it to a survey

sample consisting of (18) students from the third grade outside the study sample, where the difficulty factors ranged from (0.52-0.82) and the discrimination factors (0.32-0.59). These values are acceptable for this study procedure (Allam, 2016). To verify the stability of the tool, it was applied to the survey sample twice, two weeks apart between the two applications. The Cronbach Alpha coefficient was calculated, which measures the consistency of study individuals' answers to each test task, where Cronbach's alpha parameters ranged from 0.54-0.83. These values are considered acceptable for this study (Odeh, 2010). The time required for the test was also calculated after applying it to the survey sample by calculating the mean of the time needed by each student, the time required for the test was (40) minutes.

Test of Mathematical Achievement

After reviewing the theoretical and research literature (Tashtoush et al., 2020 a; Jedlicka, 2017; Swanson, et al., 2015; Tashtoush et al., 2022 a), a mathematical achievement test was prepared, consisting of (14) multiple choice paragraphs according to the first four cognitive levels of Bloom's: (Remember, Understand, Apply, Analyse). It included various mathematical tasks that dealt with the multiplication of numbers for the third-grade level. A specification table was prepared for the test, giving one score for each correct answer, and zero for the wrong answer, thus varying the value of the test scores from a min. of (0) to a max. of (14). To verify the apparent validity of the test in terms of linguistic wording, clarity, and comprehensiveness, it was presented to a group of experienced and competent arbitrators. In light of their opinions, observations, and suggestions, some tasks were modified in terms of their linguistic and logical formulation, such as addressing students and not specifying a certain method of solution in any of the test tasks. To verify the validity of the test construction, the test was applied to the survey sample. The difficulty factors and discrimination factors were also calculated for all test tasks. The difficulty factors for the tasks ranged between (0.2 - 0.81), and the discrimination factors ranged from (0.44 - 0.83). These are acceptable values for the study (Odeh, 2010). The stability coefficient of the test was also calculated using the Cronbach Alpha equation after being applied to the same sample, and the overall stability coefficient of the test was (0.74), which is an acceptable value for the study (Allam, 2016).

Qualitative Scoring Rubric

By reviewing the theoretical and research literature (Linda, 1999; Sahin & Baki, 2010; Abu Obeid, 2011) to reveal the levels of conceptual understanding of mathematical concepts, a qualitative scoring rubric has been prepared to analyze the students' performance on the mathematical conceptual test. Table (1) shows performance indicators.

TABLE 1
QUALITATIVE SCORING RUBRIC

Task	Performance Indicators	Scour
Task 1	The student cannot determine any way to multiply	0
	The student can determine how to multiply but cannot implement it or implement a part of it	1
	The student performs multiplication using one of the four methods with some errors in the result	2
	The student solves the task using one of the four methods and reaches the final answer with the solution steps clear and the outcome correct	3
	The student solves the task using more than one method and justifies choosing the method used among the available solution methods	4

Task 2	No attempt was identified for the approximation process, meaning that the student did not realize what was required from the task	0
	Trying to approximate and wrong result, or determining the multiplication method and not implementing it or implementing part of it, or determining the multiplication method with some errors in its implementation	1
	The approximation process is wrong and there is an error in the steps for multiplying	2
	The approximation process and determining the multiplication method are correct, but there are some errors in sub-multiplication	3
	The approximation process is wrong, but the student determines and multiplies the method correctly	4
	Correct approximation, multiplication in one of the four ways, performance and result are correct Correct approximation and solution, with justifying approximation and the choice of multiplication method used Correct approximation and use more than one method to perform multiplication.	5
Task 3	Not specifying any method of multiplication, meaning that the student did not realize what was required in the task	0
	Determine the multiplication method, and not perform it or any part of it	1
	Perform multiplication by choosing one of the four methods, with some errors in the result, or not completing the solution to get the final answer.	2
	Solve the task using one of the four methods to reach the final answer, the clear solution steps, and the correct result	3
	Solve the task using more than one method while justifying choosing the method used among the available solution methods	4
Task 4	No attempt to solve the task, analyze, or write the numbers mentioned in the task	0
	Attempts to solve by multiplying the number in the task without specifying a unit	1
	Perform multiplication, with some errors and using the correct unit in the answer Perform a correct multiplication and use the correct unit in the answer Perform multiplication correctly while not selecting the unit or selecting the wrong unit	2
	Perform multiplication correctly to get a correct answer and use the correct unit for the answer Identifying the task given and required data, then performing multiplication by the correct number with justifying, and putting the correct unit for the answer	3
Task 5	No attempt has been made to solve	0
	Writing numbers from 1 to 10 and writing their squares with some errors in the values of the squares Writing the number squares but not selecting any of them to answer the task	1
	Writing the numbers from 1 to 10 with their squares with the wrong identification of numbers whose squares fall within the required range Write the numbers from 1 to 10 and select the squares that fall within the required range	2
	Correctly identify the squares that fall within the range required by the task and specify the answer by the roots of these squares	3
	Write the squares and identify their values of them that fall within the required range of the task, justifying the relationship between the number and its square, and selecting the numbers to which these squares belong.	4

Based on this rubric, students participating in the study were classified into three levels for the development of mathematical concepts as follows: High, Medium, and Low according to the following criteria:

TABLE 2
LEVELS OF MATHEMATICAL CONCEPTS

Level	Grade
Low	0 – 6
Medium	7 – 13
High	14 – 20

To verify the validity of the rubric, it was presented to a group of arbitrators from specialized university professors, who were asked to provide their opinions and comments on the performance indicators, their suitability for the objectives for which they were set, the soundness of the language formulation and its affiliation to the fields of study. Based on the arbitrators' opinions, amendments were made until the rubric was finalized. To verify the stability of the rubric, two researchers evaluated a sample of students' answers with a two-week difference between the two evaluations and compared their results independently. The agreement factor between them was measured using the Holsti equation, and the concordance ratio between them was (0.93).

Cognitive Training Program for Children (CTPC)

The second unit (Multiplication 1) was selected from the first semester of the math curriculum for the third grade in Jordan, which included the lessons (Multiplication (1), Multiplication (2), Squares of Numbers, Review), a table of specifications was also prepared for the unit, based on the topics learned, and determining the relative weight of each lesson. The program consists of (13) classroom sessions, each of which needs the teacher to work with the students during the class to help them understand and learn to solve several problems, mostly represented by colorful drawings. The CTPC is based on several activities that correspond to the content of the educational subject, where the program is implemented through two learning stages: The stage of guided learning, where part of the problems at this stage is based on the idea of cubes implemented by the student physically and is managed in a guided educational manner. The student must identify the steps required to achieve the correct solution, and the independent learning stage, which requires the student to try to solve the problem independently before helping her reach the correct solution or enhance her answer. Strategies are discovered for each item in the matter, so that students understand the appropriate strategy to be used later in a similar matter, in this way, advice is provided on the steps and stages of training, without giving instructions to her directly (Klauer & Phye, 2008). A guide has been created for preparing educational material lessons, following teaching them within the CTPC for two experimental groups. The number of classes allocated to each lesson, objectives, methods, strategies, and resources for both groups, and the course procedures were prepared in two versions: The first version for a first experimental group, and the second version for a second experimental group, exercises, and worksheets for both versions are included at the end of the guide. The teacher was also provided with a guide for preparing the lessons in two versions: first and second experimental groups, then discussing the details of applying the educational module developed in light of CTPC for both versions, responding to any inquiries from the teacher about the implementation of the program, and agreeing with her on the possibility of a researcher attending some classes for the three study groups: The two experimental groups to ensure the safety of the program application, and the control group to ensure that they are not subjected to training on the program. To verify the validity of the educational material and CTPC, they were presented to a group of specialists in math curricula and teaching methods, measurement and evaluation, and mathematics. The specialists were asked to give their opinion of the educational material as regards its conformity with the terms of the CTPC, its linguistic formulation, as well as its suitability for the student's level. Some

amendments were made after taking their opinions and suggestions, such as including the module manual in two separate copies for all module classes, after it was included on two copies for each class separately.

Procedures

Theoretical and research literature and previous relevant studies were reviewed, the educational material was designed according to CTPC and the instruments used in this study and to ensure reliability and validity. The teacher who applied CTPC was trained in the teaching method of the educational module according to the training program. Two of the three divisions of the school's third-grade students were randomly selected to apply to the training program. Data of the student's marks from the three divisions of the third grade were also obtained from the school records, they were considered as the pre-achievement test results, students have classified into the first and second experimental groups within the two levels: The low level and the high level, as the low level includes students with a score of less than 70% in mathematics in the third grade, and the high level includes students with a score of 70% and above. The value of the 60^{th} percentile was used to make the difference between low and high levels, which is equal to 70% based on the study sample scores. The study instruments were applied to both study groups before starting the training program. Some classes were attended for control and two experimental study groups to ensure the validity of program implementation. Study instruments were applied to the three groups, papers on developing mathematical concepts, achievement, monitoring student scores, and collecting data tests were corrected, and appropriate statistical analyses were also made using SPSS. Finally, results were extracted, discussed, and interpreted to reach recommendations and suggestions.

Data Analysis

To achieve a statistical analysis after training on the CTPC, data were entered into computer memory and analyzed using SPSS to answer the study questions, percentages, and means of students' grades in math concepts and math achievement tests to detect apparent differences in means. ANCOVA test was also used to analyze the results of the achievement test.

Results

The First study question aimed to investigate the impact of CTPC on developing conceptual understanding levels of mathematical concepts, to satisfy this goal, the student's written answers to the Mathematical Concepts Development Test were analyzed according to the qualitative rubric, calculating the numbers and percentages of students, extracting arithmetic averages of their responses to the test tasks and classifying them according to the levels of mathematical concepts development (high, medium, low). Table (3) shows this.

TABLE 3
NUMBERS, PERCENTAGES, AND MEANS FOR THE POST-MATHEMATICAL CONCEPTS TEST

Group	Task	Level of conceptual understanding			Mean	Levels of Conceptual Understanding
		Low	Medium	High		
		No %	No %	No %		
Experimental 1	1	10 26%	12 31%	17 44%	15.2	high
	2	12 31%	15 38%	12 31%	11.6	medium
	3	10 26%	13 33%	16 41%	14.6	high
	4	09 19%	11 28%	19 49%	15.1	high
	5	11 28%	17 44%	11 28%	12.9	medium
	Total	**39 100%**	**39 100%**	**39 100%**	**12.4**	**medium**
Experimental 2	1	08 22%	10 28%	18 50%	14.6	high
	2	09 25%	14 39%	13 36%	12.6	medium
	3	07 20%	11 30%	18 50%	14.3	high
	4	10 28%	14 39%	12 33%	12.3	medium
	5	08 22%	11 30%	17 48%	16.1	high
	Total	**36 100%**	**36 100%**	**36 100%**	**14.6**	**high**
Control	1	16 42%	12 32%	10 26%	4.6	low
	2	13 34%	14 37%	11 29%	10.3	medium
	3	17 45%	11 29%	10 26%	5.9	low
	4	17 45%	12 32%	09 24%	4.8	low
	5	15 39%	12 32%	11 29%	5.3	low
	Total	**38 100%**	**38 100%**	**38 100%**	**5.5**	**low**

It is noted in Table No. (3) that the level of conceptual understanding of third-grade students was high for the students of the second experimental group who received training through CTPC individually, the mean of this group was (12.4), while the level of conceptual understanding was medium for the students of the first experimental group who received training through CTPC in groups, the mean of this group was

(14.6). As for students of the control group who did not receive any training in CTPC had a low level of conceptual understanding, the mean of this group was (5.5).

The second study question amid to investigate the impact of CTPC in improving the student's achievement, to satisfy this goal, the collected data on the achievement test were analyzed by extracting means and standard deviations for the pre and post-achievement test applications according to the teaching method. Table (4) shows this.

TABLE 4
MEANS AND SD FOR THE PRE AND POST-ACHIEVEMENT TEST APPLICATIONS

Test	Statistical	Experimental 1	Experimental 2	Control
Pre-application	**Mean**	79.65	79.72	77.88
	SD	14.78	15.24	13.03
Post-application	**Mean**	82.06	85.67	78.95
	SD	14.33	14.12	16.97

Table (4) shows that there are apparent differences in the means of students' performance on the post-achievement test. The mean of the first experimental group was (82.06), for the second group was (85.67) and the control group was (80.06). To show the statistical significance between means, the ANCOVA test was used for the post-achievement test between the three study groups. The results were as shown in Table (5).

TABLE 5
ANCOVA & EFFECT SIZE FOR THE POST-ACHIEVEMENT TEST

Contrast Source	SS	df	SM	F	Sig	Eta Square	Effect Size
Post	5291.36	2	2645.68	121.52	0.000*	0.450	Large
Error	2395.29	110	21.77				
Total	6071	112					

* significance level $\alpha = 0.05$

Table (5) shows that the F calculated value is a statistical function of the post-achievement test, indicating that there are statistically significant differences between the three study groups in the post-achievement test, and a Post-Hoc Analysis test was used to show the significance of the differences between the three groups. Table (6) shows this.

TABLE 6
SCHEFFE' TEST FOR THE POST-COMPARISONS OF THE POST-ACHIEVEMENT TEST

Group	Group			
		Experimental 1	**Experimental 2**	**Control**
	Mean	82.06	85.67	78.95
Experimental 1	82.06	-	3.61*	3.11*
Experimental 2	85.67	-	-	6.72*
Control	78.95	-	-	-

* significance level $\alpha = 0.05$

Table (6) shows that there are statistically significant differences at the level of significance (0.05) between the mean scores of students in the groups. The students of the two experimental groups outperformed the students of the control group in the post-achievement test. The students of the second experimental group, who were trained in small groups, outperformed the students of the first experimental group who trained individually.

DISCUSSION

The results of the study indicate the positive impact of the CTPC in improving the level of conceptual understanding and mathematical achievement among students in both experimental groups compared to the control group. This may be because the CTPC has provided a new educational opportunity that contributes to moving students out of the traditional learning environment to a flexible method that tends to get out of the ordinary in learning, and creating an atmosphere of fun and freedom of movement in the classroom during classes to provide opportunities for effective learning and participation in activities to enable students to have a deep understanding of mathematical concepts at the end of each lesson or topic of the module. The reason can also be attributed to the fact that the presentation of the training program helped students to identify similar issues that require the same method of solution. The program's description of the teacher's role while teaching the subject may have an impact on this, while the program has designed a role for the teacher to encourage students to ask questions, emphasize the most important previous requirements, link them to current learning, in addition to accepting ideas and explanations that students were presented during each educational situation, indicating that training on the program requires effective participation from the teacher, and this requires teacher planning to do it in advance and design an educational experience that will facilitate the participation of students, in addition to the continuity of the evaluation process throughout the classroom, because students cannot be directed to a new level of thinking unless they have reached the previous level. This agrees with the results of some studies (Fannakhosrow et al., 2022; Wexler et al., 2016; Shman-East, 2015; Jedlicka, 2017; Tashtoush et al., 2022 a) on the effectiveness of CTPC in improving student's achievement, and disagrees with the result of (Barkl et al., 2012) study which revealed that training on the program does not affect students.

The results had a greater positive impact in favor of the second experimental group, which was trained on the program in small groups compared to the first experimental group, which trained on it individually. This improvement can be explained by the emphasis of CTPC on participatory work in small groups, the availability of opportunities to exchange opinions freely within the same group, and the contribution of students to suggest a solution that may bear both right and wrong, the initiative of students to make these suggestions at the beginning of the solution helped to do so, allowing each student to evaluate her ideas, compare them with the opinions of her colleagues and raise her enthusiasm and motivation to achieve the correct answer, students in the small group discuss the concept of multiplication or a method of solving the problem through stages and steps in which the student stops and thinks about the true meaning of the multiplication process and the goal achieved in each step of solving the problem, this is based on previous knowledge of mathematical concepts and topics in previous lessons or even in previous classes, which enhances her ability to use this method and her awareness of why it is used in a particular situation rather than another, or may have made her change from using this method to replace it with another one that she considers more appropriate for the situation she is discussing, thereby increasing her ability to a deep understanding of the mathematical concept, helps her evaluate the answer step by step, improves her ability to detect mistakes that she may fall into, and try to correct these mistakes within the same group before presenting them to the teacher, which creates a greater awareness of the method used and its suitability to solve such problems, plus that when the student plays more than one role within the same group during the solution, may make the student's role more effective in contributing to the solution.

The results also showed the effectiveness of the program in improving the ability of students to determine the appropriate method of multiplication based on the number of digits of the two multiplied numbers in the two experimental groups, with a greater positive impact in favor of the second experimental group. This may be due to the program's interest in the four methods of multiplication, then showing the

advantage of each of them and the cases that suit them through the various activities and various cases to which these methods were applied while providing students with the opportunity to identify the advantages and difficulties of their implementation. This interest has increased among members of the second experimental group, who were trained on the program in small groups, perhaps for the participatory role in proposing and implementing the steps to solve the problem, and to benefit from presenting different ideas and opinions from members of the small group among them, as indicated by some studies (Rasheed & Tashtoush, 2021; Reyes & Amarnanim 2015; Tashtoush et al., 2022 b; Swanson, 2014; Tashtoush et al., 2023).

The results also showed that students have some misunderstanding of the concept of multiplication using the fourth method (the method of analyzing the two numbers). This may be due to several things, including that this method is unusual for students and requires continuous training on it, plus that this method requires multiple steps and stages that include more than one calculation, in addition, students in the early stages tend to have easy methods, so they choose the easiest method to use when given the freedom to choose how to solve the problem.

Recommendations

In light of the good impact of CTPC found in the current study, the researchers recommend the importance of training teachers of the early primary levels on CTPC because of its importance in developing an understanding of mathematical concepts and mathematical achievement, and conducting more studies that develop the level of understanding mathematical concepts and mathematical achievement among students using different programs and teaching strategies that suit the age stages of learners, in addition to conducting other studies that deal with CTPC, considering samples and other variables to solve the issue, motivation to learn, and mathematical thinking of all kinds, mathematical justification, and academic enthusiasm.

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