

The Effect of Open-ended Tasks –as an assessment tool- on Fourth Graders' Mathematics Achievement, and Assessing Students' Perspectives about it

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Abstract: The open-ended task constitutes an effective type of assessment. This study aimed at investigating the effect of open-ended tasks on fourth graders' mathematics achievement and assessing students' perspectives about it. The sample of the study consisted of (135) fourth grade students, from four sections, distributed randomly to an experimental group who were assessed during the "9-digit Numbers" unit by exposing them to open-ended tasks, and a control group who were assessed using the traditional method of instruction. Results of the study revealed that open-ended tasks had a positive effect on improving students' mathematics achievement, and assessing their perspectives toward using the tasks in learning mathematics. (**Keywords:** Open-ended task, Mathematics, Achievement, Perspectives).

أثر استخدام المهمات مفتوحة النهاية - كأداة تقييم - في التحصيل الرياضي لدى طلبة الصف الرابع الأساسي وتقييم وجهات نظرهم حولها

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ملخص: تشكل المهمات مفتوحة النهاية نمطاً فاعلاً في التقييم، وقد هدفت هذه الدراسة إلى فحص أثر استخدام المهمات مفتوحة النهاية في التحصيل الرياضي لدى طلبة الصف الرابع الأساسي، وتقييم وجهات نظرهم حولها. وقد تكونت عينة الدراسة من (135) طالباً من طلبة الصف الرابع، موزعين على أربع شعب تم تقسيمها عشوائياً إلى شعبتين كمجموعة تجريبية درست وحدة (الأعداد ضمن 9 منازل) من خلال المهمات مفتوحة النهاية، وشعبتين كمجموعة ضابطة درست الوحدة نفسها بالطريقة التقليدية. وقد أظهرت نتائج الدراسة أن المهمات مفتوحة النهاية لها تأثير إيجابي في تحسين التحصيل الرياضي لدى الطلبة. وتقييم وجهات نظرهم نحو استخدام المهمات في تعلم الرياضيات. (الكلمات المفتاحية: مهمات مفتوحة النهاية، رياضي، تحصيل، وجهات النظر).

Introduction: Assessing Students' Understanding:

Assessment refers to activities, used both by teachers, and their students, that provide information and feedback to modify the teaching and learning activities (Black & William, 1998). "Teachers are encouraged to make use of the results of assessment of learning to benefit the learners by reviewing their performance in the assessment activities with them and working out a plan for further improvement" (Schuwirth, 2010: 171). In this way, the whole change in thinking about assessment in the educational environment has led to changes in the purpose of conducting assessment activities, which is extended from assessment of learning to assessment for learning.

The Assessment Standards for School Mathematics (NCTM, 1995) recommends that classroom assessment should reflect the mathematics that students should know and are able to do. NCTM (2000) views assessment as a component of instruction that best informs and guides teachers as they make instructional decisions, and students as they make judgment of what is important to learn.

There are many "assessment types of student's understanding and thinking" (Bush & Greer, 1999, p.34), which can be classified as follows:

- Closed tasks, such as multiple choice, true / false items, solve simplify...etc.
- Open tasks, such as open – middle tasks, which have one correct answer with multiple alternatives to the solution, and open- ended tasks, which have multiple answers and approaches to the solution.
- Projects, such as short projects, extended projects, presentation.
- Informal assessment, such as class discourse, journals, conversations.

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Problem Solving and Open Tasks:

Problem solving is one of the National Council of Teachers of Mathematics standards, which requires posing students with real situational tasks that can be solved by different methods to reach to several correct answers. In NCTM (2000), it is stated that “Solving problems is not only a goal of learning mathematics, but also a major means of doing so...In everyday life and in the workplace, being a good problem solver can lead to great advantages... Problem solving is an integral part of all mathematics learning” (p. 52).

“Problem solving is a goal directed thinking and action in situations for which no routine solution procedure is available” (Reeff, 1999: 48). The problem solver has a more or less well-defined goal, but does not immediately know how to reach it. Liljedahl (2004) presented a group of pre-service elementary teachers a set of mathematical problems to solve. Some of the tasks allowed a form of mathematical discovery that he called a “chain of discovery”. They helped to change the student teachers’ negative beliefs and attitudes.

Open problems tasks are said to be open, if their starting or goal situation is not exactly given (Pehkonen, 1995), meanwhile, the task is said to be closed, if the starting situation is exactly given, in other words, the task is well-defined, and has one result. In open tasks, pupils may end up with different, but equally correct solutions; so, open tasks usually have several correct answers. Foong (2002) describes open-ended problems as “ill-structured” because they involve missing data, and they have no fixed procedures that guarantee a correct solution. Students need to enlarge their existing knowledge to engage the problem situations. Open problems provide more opportunities for varied ability students to demonstrate their mathematics ability (Wu, 1994).

Open-ended problem tasks can foster higher-order thinking and promote reflection (Dyer & Moynihan, 2000). When a student learns mathematics through open tasks, he struggles with the difficulties facing him, which promotes “deep understanding” of the mathematics that is valued (Hiebert et al, 1996). The educational task that reveals more of children's thinking than the common alternatives is using open assessment tasks (Cheeseman & Doig, 1995).

Capraro; Capraro & Cifarelli (2007) suggested some benefits of Open-ended Problem Solving, such as:

- It provides a suitable learning environment for students to develop and express their mathematical understandings.
- It allows for different correct solutions, and every student can respond to the problem in his own way.
- It is important to involve every student in the activities and lessons.

- Students can use mathematical knowledge and skills, comprehensively.
- With many different solutions, students can choose their favorite strategies to answer the problem, and this enables teachers to conduct discussions with students about the strategies that are used by students to solve problems.
- Students are able to give other students reasons for their solutions.

Mathrex (Mathematics Reasoning Exercise) was a good way to engage students in learning mathematics (Eric, 2005); it was introduced to enable students to work in small groups to solve open-ended mathematics problems, which provide an opportunity for students to generate several solutions, and group discussions to make and justify decisions.

Bush and Greer (1999) had set the following evidences of students’ understanding and thinking based on open tasks:

- Apply all descriptors from the closed tasks.
- Know the what and the why in using mathematics in different settings.
- Solve problems in a mathematical or real world context.
- Use various strategies and justify the strategies.
- Organize and interpret information.
- Interpret solutions in a more complex setting.
- Verify results.
- Solve problems and reason.
- Use or create mathematical models in order to solve problems.
- Communicate thinking.
- Connect to prior learning experiences or to mathematical topics.
- Work alone and in groups for a short time (p. 35).

Assessing Open-ended Tasks:

Open-ended tasks assessment allow for a variety of approaches or answers that make it possible for everyone to be successful, and generate exciting classroom discussions (Riverstone & Fung, 2007); it can easily and efficiently measure students’ higher-order thinking skills (Cai, 1997), and it can provide students with unique learning opportunities to extend their conceptual knowledge and deepen their understanding (Cifarelli & Cai, 2005; Capraro, Cifarelli, Capraro, & Zientek, 2006). So, the use of open-ended tasks gives the teacher an additional alternative assessment method to measure students’ performance in a different method, which reveals students’ mathematical thinking during the work with the open-ended task.

There are many assessment strategies and tools that can be used when giving students open-ended tasks. In addition to paper and pencil strategy, the teacher can observe the student while solving the problem, and he can use a checklist or a rating scale to assess every specific item of the problem. The teacher can use a portfolio to collect students' responses and works.

An open assessment task has a certain structure when it is used; it requires the child to write, draw, or construct a response to a question, and requires that each child has a copy of the question or questions, and the means to record or construct their response. To assess students work on open-ended tasks, they will not be machine scored, instead of that, there must be a scoring rubric, which depends on the type of question that is asked and the type of response that is required of students, it may be 0-1, 0-2, or 0-3 point, or any thing similar. Attali and Powers (2010) stated that the immediate feedback on the correctness of students' answers to open-ended questions allows them to revise their answers following feedback. This can improve their achievement and decrease their anxiety, which in turn can increase their attitudes toward mathematics.

The current study aims to examine the effect of open-ended tasks -as an assessment tool- on fourth graders' mathematics achievement, and to assess their perspectives about it. Specifically, this study tried to answer the following questions:

- 1- Is there any statistically significant difference between means of the experimental group (which was assessed by using open-ended tasks), and the control group (which was assessed traditionally) on the achievement test?
- 2- What are the fourth graders' experimental group perspectives about using open-ended tasks in learning mathematics?

Research hypotheses:

The current study aimed at testing the following hypotheses:

- 1- There is no statistically significant difference at a significance level ($\alpha=0.05$) between the mean scores of the experimental group and the control group on the achievement test.
- 2- The assessment of the perspectives of fourth graders' experimental group shows no effect of using open-ended tasks in learning mathematics.

Procedural Definitions:

- **Open-ended Task:** is an assessment type of the assessment process, which requires posing the student with a mathematical question, which have multiple answers and approaches to the solution.
- **Mathematics Achievement:** is the knowledge, understanding, and skills that student exquisite as a result of a specific educational experience. The

achievement is measured by the students mark on the achievement test, which is developed by the researcher to be applied in this study.

- **Students' perspectives:** are trends qualifying student to respond to things he likes or dislikes in mathematics, in specific psychological patterns. The perspectives are measured by the frequencies of the experimental group students' responses to the questionnaire about the effect of using open-ended tasks in mathematics.
- **UNRWA:** United Nations Relief and Works Agency for Palestine Refugees in the Near East.
- **Fourth-Graders:** students' age 9-10 years, who were in the fourth grade in the scholastic year 2011/2012.

Limitations of the Study:

- Instruments of the study were developed by the researcher, so the interpretation of the results depends on the validity and reliability of these instruments. Though the researcher verified these psychometric characteristics.
- The study was applied to UNRWA schools in Zarqa area, and this makes the generalization of results specific to the study population or a similar community.

Methodology and Procedures:

Study Sample:

The population of the study consisted of all fourth graders at UNRWA schools of Zarqa area, in the scholastic year 2011/2012. The sample of the study consisted of four sections from Marka School, which was specifically and on purpose selected from Zarqa Area schools. Two sections were selected randomly as an experimental group, who were assessed by using open-ended tasks, and the other two sections were selected as a control group, who were assessed by the traditional method, and the four sections were taught by the same teacher. Table (1) shows the number of students participating in the experimental group and the control group.

Table (1). The Distribution of the Study Sample on the Study Groups

Group	No. of Students
Experimental	68
control	67

Instruments of the Study:

Open-ended Tasks:

Open-ended tasks were designed by the researcher, and developed by the help of the experimental group teacher, to clear the application conditions during the learning process. A detailed explanation was introduced to the teacher of how to plan to use open-ended tasks in

the lesson activities and assignments. For example, the teacher gives the students an open-ended task related to the subject learned, during the instructional process, as an assessment tool, and he follows-up the solution that is introduced by the student, then he discusses the task with the class. The teacher also can give the students an open-ended task as a homework activity to be solved by the student, then to discuss this task with the class in the coming lesson.

The tasks were distributed to the experimental group during the study period, (nearly, a daily task), and students were asked to work on these tasks, sometimes individually and sometimes in groups. The open-ended tasks were applied during the regular mathematics

lessons, in the “9-digit Numbers” unit, in addition to the tasks written in the textbook. The control group was taught the same unit traditionally, by using the tasks in the textbook only. Appendix (A) reveals a study plan that includes using an open-ended task in its procedures.

The Achievement Test:

Depending on content analysis, an achievement test was designed and conducted on test students’ mathematical knowledge taught in unit “9-digit Numbers”, from the fourth grade mathematics curriculum in the scholastic year 2011/2012. Table (2) revealed the specification table of the achievement test.

Table (2). The Specification Table of the Achievement Test

The content	Procedural knowledge	Conceptual knowledge	Problem solving	Total
Million	2	5	1	8
Comparison of numbers	2	2	2	6
Arrangement of numbers	2	2	2	6
total	6	9	5	20

The test was developed to consist of (20) multiple choice items, every item has three alternatives, one of these alternatives is correct. After the completion of the workout of the achievement test, it was given to a panel of judges to give notes about the validity of the items and the overall test. Their remarks were taken into consideration, and the corrections were made. To establish the reliability of the achievement test, it was applied to (37) students from the population of the study. Those were not included in the sample. A difficulty and discrimination coefficients of the test items were computed, which ranged between (0.28 – 0.91), and by using a Split-Half method, a Spearman-Brown Formula, it was found out that the reliability coefficient for the overall test was (0.81) which is an accepted value for the research purposes. Appendix (B) reveals the achievement test in its final form.

Students’ perspectives questionnaire about open-ended tasks:

Students in the experimental group were exposed to the open question: “What are the effects of using open-ended tasks on your learning of mathematics?” and they were asked to write in short sentences their feelings about the effect of using open-ended tasks during the learning of mathematics. Students were helped by the teacher in deducting some thoughts during completing the questionnaire. The perspectives are measured by the frequencies and percentiles of the experimental group students’ responses about the effect of using open-ended tasks in mathematics.

Study Procedures:

- The experimental-group teacher, who participated in the application of the study, was trained on how to use open-ended tasks in mathematics classes.

- The experimental group was assessed during their study of the unit “9-Digit Numbers” by using open-ended tasks in the regular mathematics lessons, in addition to the textbook; Meanwhile, the control group was assessed by the traditional method using the textbook only.
- After the completion of the study, a mathematics achievement test was administered to the two groups, and students’ perspectives questionnaire about open-ended tasks was given to the experimental group. The results were analyzed by using SPSS program to test the hypotheses of the study.

Study Variables:

- 1- Independent variable: Assessment method, which has two levels:
 - a) assessment using open-ended tasks.
 - b) assessment traditionally.
- 2- Dependent variables:
 - a) Mathematics achievement.
 - b) Students’ perspectives about open-ended tasks.

Statistical Treatment:

To test the first hypothesis of the study, ANCOVA was used to compare between the means of the two groups in the mathematical achievement test. To test the second hypothesis of the study, frequencies and percentiles were used to enclose students’ perspectives about using open-ended tasks as an assessment tool on learning mathematics.

Study Results:

Students’ mathematics achievement results of the third grade were administered as a pre-test, which were

the latest marks the student achieved before he participated in the study.

To examine the hypothesis: “There is no statistically significant difference at a significance level ($\alpha=0.05$) between the mean scores of the experimental

group and the control group on the achievement test”, descriptive statistics of the two groups on the achievement post-test and the estimate values - in relevance to the pre-test results - were computed. They are shown in table (2) as seen below:

Table (2). Descriptive Statistics of the Two Groups on the Achievement Post-test and the Estimate Values in Relevance to the Pre-test

GROUP	N	Pre-test		Post-test		Estimates	
		Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Error
Experimental	68	78.44	9.83	15.37	1.99	15.50	0.21
Control	67	80.03	9.85	13.75	2.75	13.61	0.21

Table (2) revealed that there were apparent differences between the means of the two groups, in the post-test and the estimate values. To examine the

significance of these differences, the ANCOVA test was administered. The results are shown in table (3) seen below:

Table (3). ANCOVA Test Results to Compare between the Two Groups on the Achievement Post-test in Relevance to the Pre-test

Source	Sum of Squares	Df	Mean Square	F	Sig.
PRE	362.99	1	362.99	118.75	0.00
GROUP	119.53	1	119.53	39.10	0.00
Error	403.50	132	3.06		
Total	855.22	134			

Table (3) revealed that there were statistically significant differences between the means of the two groups, since the F- value was (39.10), and with significant level (0.00), which was less than the critical value (0.05).

Analyzing the results shown in table (2), and comparing the estimated means of the two groups, it was found out that the estimated mean of the experimental group (15.50) was greater than the estimated mean of the control group (13.61), and this means that the achievement of the experimental group was much better than that of the control group. This result refutes the first hypothesis.

This result seems to be a logical one since using open-ended tasks gives the opportunity for the student to think deeply, and make connections between the ideas that are required to solve problems, which make him aware of the mathematical concepts, skills, and generalizations, so that he can use these kinds of knowledge easily, and therefore he can achieve mathematics goals. In addition, when teachers use open-

ended tasks, they can assess students' misunderstandings by examining their thinking, which is a good alternative assessment method to develop students' conceptual understanding and increases their achievement levels.

This result of the study coincides with the study results of (Cai, 1997; Dyer & Moynihan, 2000; Riverstone & Fung, 2007; and Attali & Powers, 2010) in the positive effect of using open-ended tasks in improving the mathematics achievement.

To examine the hypothesis: “The assessment of the perspectives of fourth graders' experimental group shows no effect of using open-ended tasks in learning mathematics”, students' perspectives questionnaire responses were gathered through analyzing the written sentences on the open question, which was given to the experimental group: “What are the effects of using open- ended tasks on your learning of mathematics?”

Table (4) below shows students' perspectives about using open-ended tasks in learning mathematics:

Table (4). Students' Perspectives about Using Open-ended Tasks in Learning Mathematics

No.	Item	Frequency	Percentile
1	It makes me learn mathematics easily	53	0.78
2	It makes me solve problems in different ways	46	0.68
3	It makes me feel pleasure in learning math	41	0.60
4	It makes me think clearly	39	0.57
5	It makes me solve real world problems	32	0.47
6	It makes me co-operate with my friends	24	0.35
7	It makes me imagine strange things	13	0.19
8	It helps me discover my mistakes	9	0.13

The experimental group students' perspectives shown in table (4) reveal that using open-ended tasks makes learning mathematics easier (78% of the experiment group claimed that), and it constructs an important belief about the possibility of solving problems in different ways (68% of the experiment group claimed that).

In general, the use of open-ended tasks affects students' beliefs and thoughts in learning mathematics, which may happen because each student had the chance to reveal most of his ability, through exposing himself to the task that requires the appearance of his or her extreme effort to solve the problem, which puts the student in a challenge with himself to reach the solution.

This result of the study coincides with the study results of (Liljedahl, 2004; Capraro; Capraro & Cifarelli, 2007; and Attali & Powers, 2010) in the positive effect of using open-ended tasks in enhancing students' perspectives toward learning mathematics.

Conclusion:

Open-ended tasks can strengthen students' knowledge through forcing them to think of the mathematical problem using their extreme abilities to reach the alternative correct answers if found, and this is revealed in the current study through improving students' mathematics achievement.

When students solve the problem, they feel that they learn mathematics, because they know that the solution does not come trivially, but it requires using their best efforts, so this can positively affect their confidence of their abilities, which may reflect favorably on their perspectives about using open-ended tasks in assessing their achievement.

If the student attempts to answer the open-ended questions, this reflects a belief that mathematics represents a logical system of relationships, rather than mere computation, because it requires from the students in the experimental group to organize their thoughts and then compose the introductory sentences of their answer, since they use a greater number of different words and complex expressions than those in the control group.

This may lead to fostering the building of new knowledge in learners' zones of proximal development, so the item in the questionnaire applied in this study "It makes me learn mathematics easily" has a greater frequency and percentile of the items, which means that using open-ended tasks has an obvious impact on students' impressions about learning mathematics.

Students who use the open-ended approach may become most successful at solving a problem in all of its aspects; meanwhile other students may become fixated on a single aspect of the problem, moreover, this approach encourages collaborative learning, gives

indicators to students' progress, and helps in identifying student misconceptions, so there is a need to develop open-ended skills throughout the mathematics curriculum.

Recommendations:

It is recommended to use open-ended tasks in assessing students' learning of mathematics. For future work in this area, researchers might conduct other studies to examine the effect of open-ended tasks on samples of other grades and other communities.

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