Design and Assessment of a Mathematics Module in Line with TIMSS

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***Abstract* – In this paper we report on our aims to design a mathematical unit in line with Trends in International Mathematics and Science Study, TIMSS, see Appendix-1, and to assess the impact of this proposed design on the thinking of the second intermediate students in Najaf. The unit was designed according to: i) the two steps of the original educational design and ii) the skills included in the global project. The mathematical content was: relative numbers, real numbers, and algebra. The sample consisted of 60 students from the secondary schools in Najaf, divided into 2 groups: the experimental group of 30 and the control group of 30 students. The selection was done in a simple random way. The research tools were pre-test and post-test, both of which were built to measure the forked thinking according to 4 strategies: i) correlation analysis, ii) analysis of views, iii) complementarity, and iv) network analysis of relations. We used Kuder and Richardson Formula 20, see Appendix-2, T- test for two independent samples and T- test for statistical samples interconnecting means. The results showed: i) there were statistically significant differences between the pre and post test of the experimental group, ii) the existence of statistically significant differences between the post-test of the two research groups, iii) both in favor of the design of the proposed unit. The results are followed by a set of recommendations.**

Keywords - Mathematics, Mathematical Thinking, TIMSS, Design of a Mathematics Module.

I. INTRODUCTION

The importance of thinking about human life as a result of its multiple uses in the building of civilizations is a blessing of the uniqueness of man from the rest of creatures. In order to preserve this blessing, we must identify the different ways of thinking and where knowledge exists, man has found a good environment to stimulate and develop thinking. The book is at the forefront of the environmental elements that humans interact with.

The learning of mathematics is an advanced position in the subjects of study as a result of its reliance on logic, accuracy, depth and rationality. We must resort to mathematics when talking about thinking and its methods. If the thinking is one of the modern types of thinking, it is possible to search and investigate this type of Thinking and measuring students when teaching subjects in mathematics.

There are not many observations on the mathematics books in Iraq as a result of achieving objectives that require the abilities of students and develop mathematical thinking, but it is possible to benefit from the global experience in this regard, even if we learn about the global trends we find the draft international trends for the study of mathematics and science (TIMSS) International mathematics in the ages (10 and 14 years) that will stimulate thinking and increase achievement.

Therefore, the researcher saw the need to design a unit of study in the book of mathematics, taking advantage of these international trends and knowledge of their impact on the thinking of the second intermediate students of excellence, in an attempt to develop this type of thinking among students and to send a letter to future researchers of think, develop and benefit from modern global experiences including TIMSS.

A. Research Significance

The importance of research is as follows:

1. The theoretical importance of adding new content of mathematics to the intermediate stage to our curriculum (as a suggested model) which will develop students' thinking processes.
2. Keeping abreast of the developments in the world and meeting the human needs by of globalization and knowledge explosion. This axis is manifested in the content design by the global requirements advocated by developed countries including America, Britain and other countries.
3. Raising a new type of thinking within the classroom is a complex thinking, which includes a lot of strategies and facilitates the handling of exercises and complex mathematical issues and difficult to accurately reach the right solution.
4. Although excellent students have high IQs, the current research is an attempt to add something new to stimulate thinking and action in several steps and several ways to solve mathematical problems which may help in summoning the mental queues and reach the achievement of the highest goals in the level of Bloom which consists of analysis, composition and evaluation.
5. The practical importance of the use of the tests of thinking (pre-test and post-test) in the application of the middle stage, and the use of ideas and the pattern of questions to build future tests in mathematics because

of the importance of content to stimulate thinking and leave routine tests that require direct answer.

B. Research Goals

1. To design of an educational unit for mathematics by the requirements of the International Study of Mathematics and Science (TIMSS).
2. To assess the effect of the design of the proposed unit on the forked thinking of the second intermediate students in Najaf.

C. Search Terms

1. Module Design: A planning process that results in an organized plan for a set of knowledge that works to achieve a set of objectives. (Al-Ghamdi, 2011).
2. TIMSS: A global project designed to compare science and mathematics education in public education around the world so that countries can benefit from each other for many educational practices and develop science and mathematics curricula to achieve high achievement. (Al-shahri, 2017, 46)
3. Forked-Thinking: It is the thinking that makes the student in a movement in different directions, which is inspired by his ideas towards several solutions to the problem of one, and linked to this thinking creativity because it generates new ideas and solutions. (Al-Saliti, 2008, 239).

II. LITERATURE REVIEW AND CURRENT TRENDS

Attention to the mind and thinking process is one of the most important objectives of teaching mathematics, which helps students to identify and manipulate data and information, as well as to organize, analyze and interpret these data in order to find a suitable solution to mathematical problems (Diab, 2004). The Arab countries that began in the twenty first century with competition, we find the process of development and education of ideas in the forefront of its objectives as well as the acquisition of students knowledge and information, and the existence of thinking processes that enable anyone to meet the requirements of contemporary life (Ghamdi, 2011).

There is a need to teach thinking skills because it is an effective tool to achieve the goals by employing the knowledge, skills and experiences that the individual possesses properly. Proper thinking enables the person to adapt to the circumstances and to deal with the problems and difficulties facing him by recalling and employing his knowledge and skills and experiences. The more sophisticated these tools were and the stronger and more powerful they were. Thinking was the decisive factor in the issues of success in life and the more able to think was its success, the more modern education was concerned with the training of thinking processes and refining skills to become students a study on the employment of information and skills in achieving the desired success and keep pace with changes in the fields of life. (DCTT, 2015)

A. International Study of Mathematics and Science (TIMSS)

They are global trends in the development of science and mathematics education, one of which is International Testing, and TIMSS are abbreviated words from the beginning of a set of words meaning: Trends of the International Mathematics and Science Studies.

The results of these tests include a set of questions designed to measure the students' ability to analyze, interpret and solve problems. They were presented for the fourth and intermediate grades, at the ages of 10 years and 14 years. (Muhammad, 2015, 171).

B. TIMSS Project Definition

Is an international study of students' skills, knowledge and skills in mathematics and science, involving students from a group of international nations. It is designed to measure differences between national educational systems and to interpret those differences to help develop mathematics and science education and learning around the world. The tests are conducted every four years, starting with the first (1995, 1999, 2003, 2007, 2011, etc.). The test questions combine multiple choice questions with short answer questions. Mathematical content of mathematics questions includes five areas (numbers, algebra, measurement, engineering and data), and through four levels of knowledge (knowledge of facts, procedures, use of concepts, solving of routine problems and intellectual analysis). (Muhammad, 2015, 172)

Some Arab countries participated in these tests, including Egypt, Lebanon, Morocco, Syria, Palestine, Jordan, Bahrain, UAE, Qatar and Saudi Arabia, but the participation was not the required level due to the low grades obtained in both stages compared to other countries. Theoretical, applied, and useful in constructing teaching methods or building tests or analyzing content are many (Shaykhe, 2012; Ryan, 2015; Shukor, 2016; Al-shahri, 2017; Al-khatib, 2017).

C. Forked-Thinking

Abd al-Hadi (2013), states in his blog that the environment that surrounds the community is the cause of their routine thinking. It goes in one direction, but the problems of everyday life need another thinking, which requires several correct answers. One is that the thinking used to achieve this type of procedure is called (forked - thinking) and we mean the ability of the individual to form more than one alternative in one position and choose the final solution of those alternatives. (Abdel Hadi, 2013)

This type of thinking can be used when there is an educational situation that presents a problem or obstacle to the student. It requires that the student take a series of procedural steps to obtain a suitable solution. In this field, it is possible to raise the student with one or more questions or situations. Thinking has thus we make it in the position of seeking a solution or a set of solutions to that problem.

C1. Characteristics of Forked-Thinking

Imran, 2001, summarizes the characteristics of an individual who has the ability to forked-think in:

1. Able to generate a number of answers to the specific situations that he faces, as well as the ability to innovate for several solutions and discovery and expansion, and this feature makes the thinking of the most comprehensive of creative thinking because this feature overcome the skills of creative thinking of fluency and flexibility.
2. He walks freely in a multidisciplinary environment that helps him to walk more than a path, and this property shares with the creative individual.
3. Possess original skills such as (composition, authorship, perception of relationships, classification, possession of new visions, the ability to develop and improve) and this feature emphasizes the flexibility and release possibilities of the human mind.
4. The creator of course, he thinks in an unconventional way and can address the problem from all aspects (past, present and future).

C2. Strategies of Forked-Thinking:

1. Virtual Thinking: This strategy guides teachers by asking a virtual set of questions to their students, which in turn motivates them to think about situations and outcomes accompanying those positions.
2. Reverse Thinking: This strategy works to expose the student to new situations, by going out of the ordinary by looking at the problem or situation in reverse, or going backwards from the back to any of the results to the causes. The teacher also asks the student to come with questions about the mathematical subject rather than finding answers. This strategy provides an opportunity for the student to delve deeply into seeing and thinking about events and situations.
3. Various Symbolic Systems: This strategy uses symbolic systems of educational situations in an unusual or unusual way, which is not used by the student before, and the teacher can ask the student under this strategy to convert the question of verbal to mathematical symbols or expression of data geometric shapes drawn with verbal phrases or abbreviations of verbal phrases smaller than them, and others.
4. Symmetry: This strategy activates the intellectual ability of the student by looking for answers to two different questions, the student raises questions that raise similarities in finding solutions and allows him to find a link between solutions and answers to identify similarities and differences between them, and thus increase mental processes of course and more of a road.
5. Analysis of Views: In this strategy the student mentions the reason for choosing a particular method of solution or answer without the other, and the teacher can ask the student questions about evidence and evidence that support the point of view by choosing that solution or that answer or the way to find a solution by thinking carefully in those Evidence and reasons. It is possible in this strategy to deepen the student in his thinking and reflect on the appropriate idea selected only, and here is the process of analyzing the point of view of the student can be rejected or accept that opinion.
6. Completion: This strategy depends on the natural motivation to complete the situation or incomplete event, as the process of completing these situations or events make the student think in more than one direction, that is forked in his thinking, and also can find links between the original and completion , And this strategy develops a skill (prediction).
7. Analysis Network: In this strategy students analyze situations, events or mathematical issues that have more than one or more demands or solutions, or which involve difficulty in the process of solving. A set of questions about the relationships between these situations is formulated to determine the results This strategy includes the process of discovering relationships, expressing them and deriving the links, as well as shortening them in the simplest form, (Mansouri, 2017,300-296).

III. METHODOLOGY AND PROCEDURES

A. The Sample

The sample of the research consisted of (60) students from the second intermediate stage of the high school of excellence in the province of Najaf by two groups, the first experimental group (30) students, the second group was an control with 30 students. The groups were chosen in a simple random way. The second intermediate stage consisted of four divisions.

B. Equivalence of Groups

The equivalence of the research groups was done in the following variables:

1. Age of student.
2. General average of achievement in first grade.
3. Torrance test of creative thinking.
4. IQ.

The statistical results indicated that there were no statistically significant differences in the above variables,

which means that the experimental and control groups were equal in these variables.

C. The Design of the Research

The semi-experimental design was chosen for two groups to be suitable for the current research, where the tribal test was applied for the two groups at the beginning of the first semester of the 2015-2016 academic year. And then the post-test was applied to the two groups.

D. Search Tools

D1. Pre-test: The pre-test consists of (30) paragraphs of the article, and its formulation included the indirect presentation of information in order to find a way to think and find a solution, and has been verified the validity of the virtual test by presenting it to a group of specialists of mathematics teachers and supervisors as well as some of the professors of the department of mathematics at the University of Kufa and many of them have expressed their consent to the test except for some amendments have been introduced.

D2. Post-test: It was built according to the following steps:

1. The objectives of the test were to determine the achievement of the students who excel in thinking about the topics of mathematics book for the first semester in 2015/2016 and to compare the arithmetic averages that appear for the two groups in order to know the effect of the design of the unit.
2. Determination of mathematical content The following topics were: (relative numbers, real numbers, algebraic).
3. Determine behavioral goals by mathematical content.
4. Building the table of specifications, by the mathematical content on the one hand and by the behavioral goals on the other, and may be (40) forty paragraphs of the type of open questions.
5. To determine the degree and correction, the total score of the test (100) hundred degrees was determined by two and a half degrees per paragraph.
6. The validity of the test was confirmed twice. The first was the veracity of presenting it to a group of specialists in mathematics and teaching methods as well as some of the mathematics teachers. The second type of honesty was the validity of the construction by calculating the percentages of each paragraph and its relation The researcher used the method of return on a sample of (25) twenty-five students from the school of Nehag Balagha, the first test was submitted Then, after 10 days feet again taking into account the report of the students a week before the test, the alpha coefficient was used to calculate the Cronbach consistency between the application has been metric 86.5% afternoon and this factor is an acceptable educational.
7. Print the test, after taking the opinion of the arbitrators to amend some of the paragraphs and submit and delay some of the terms and numbers and not to delete any paragraph and maintain the corrective grades, the test was printed in final form of the (40) of the type of open questions and also included verbal issues.

E. Module Design

The design of the module in the mathematics book for the second intermediate grade included the following steps:

1. Determining the stages of the original design process: analysis, design, implementation, calendar.
2. Determining the mathematical skills included in the International Testing (TIMSS): observation skills, comprehension skills, application skills, comparison skills, classification and ranking skills, mathematical reasoning, and solving mathematical problems.
3. Determining elements of the unit: relative numbers, real numbers, determinants.
4. Determining each subject in mathematics according to the target content and analyzing it according to international skills and writing sports activities including practical examples and routine and non-routine issues. This design should include feedback for the students. During implementation, evaluation questions will be formulated in brief oral tests as well as a set of activities and questions homework.
5. The distribution of mathematical subjects on study plans, taking into account the time allocated to the lesson, which is 40 minutes. Therefore, the subjects of the module were distributed on more than one plan.

F. Research Procedures

The research includes the following procedures:

1. See the literature and previous studies related to the subject of the research.
2. Reviewing the tests of the types of thinking in general and the tests that dealt with the strategies of thinking in particular.
3. To review the content of the mathematics book for the second intermediate grade, which is for the academic year 2015/2016, and to write the quarterly plan for subjects according to the time.
4. Building the tribal test paragraphs by ideas extracted by the researcher as well as by the previous measures and then apply the test on both groups in the month (tenth) for the year 2015.
5. Design and presentation of the unit with the objectives of teaching mathematics for the intermediate stage as well as the objectives of the draft international trends on a group of arbitrators.

6. To develop study plans for the content of the mathematics book in the first semester by the proposed design and to train the mathematics school on two models, as well as to develop plans for the same content but with regular teaching without reference to that design.
7. Monitoring the teaching of the experimental and control groups during the trial period and observing the oral evaluation questions as well as the activities provided to the students.
8. Building the post-test paragraphs in accordance with the strategies of thinking as well as the ideas presented in the tribal test, and applying them before the final exam.
9. Tabulation of data and statistical analysis to see the results.

IV. RESULTS ND DISCUSSION

A. The First Set of Results

The effect of the unit design on the achievement of the students of the experimental group in the pre - post tests. The results were shown in Table I.

TABLE I. RESULTS OF THE EXPERIMENTAL GROUP IN THE PRE- POST TESTS

Test	Number of students	Arithmetic mean	Standard deviation	Digress freedom	T value calculated	T value tabular
Pre-	30	70.23	10.3	29	14.24	2.042
Post-	30	85.19	4.51			

Table I shows that the arithmetic mean of the experimental group in the post-test is higher than the arithmetic mean in the pre-test. In order to know the statistical significance, the t-test of the interrelated samples was applied. The calculated value (t) (14.24) higher than of tabular value (t) (2.042). Thus, we reject the null hypothesis and accept the alternative that provides for the differences and for the experimental group that studied the unit with the new design.

B. The Second Set of Results

The effect of the design of the unit on the achievement of the post-test of the two research groups, and the results are shown in Table II.

TABLE II. RESULTS OF THE TWO GROUPS IN THE POST-TEST

Group	Number Of Students	Arithmetic Mean	Standard Deviation	Digress Freedom	T Value Calculated	T Value Tabular
Experimental	30	85.19	4.51	58	3.59	2.021
Control	30	72.55	1.77			

Table II shows that the arithmetic mean of the experimental group is higher than the arithmetic mean of the control group. In order to know the statistical significance, the t-test of the independent samples was applied. The calculated value (t) (3.59) is higher than the t (2.021). Thus, we reject the null hypothesis and accept the alternative that states the existence of differences and for the benefit of the experimental group that studied the unit with the new design.

C. Discussion and Interpretation of the Results

In both sets of results, the positive effect of the design of the proposed unit is shown. The author believes that the reasons for this effect may be due to the following:

1. The design of the unit according to the International Trends Project (TIMSS) provides an environment of suspense and attraction for students because it involves a large number of skills that require their intellectual property, which has given them an incentive to make a much effort to solve problems with new ideas that led to the correct solutions.
2. The current research is consistent with all studies and research that showed the superiority of the programs, models and teaching methods used to design the contents of the scientific curriculum according to international standards, especially the project (TIMSS).
3. The existence of a stimulating atmosphere to stimulate ideas within the classroom and in the mathematics lesson specifically helps to feed different ideas among students, and this is often in the class experimental group, which makes the student eager to multiply the correct answers and choose the best ideas for the solution.
4. The tests helped the thinking of the cross-competition during the study of mathematics especially since the students are excellent and highly intelligent, making the atmosphere suitable to put more than one idea and more than one solution.

V. CONCLUSIONS AND RECOMMENDATIONS

1. Adopting the design of the proposed module to benefit from the development of mathematics curriculum, and this measure is in keeping with the new global trends.
2. Using the idea of tests based on different ideas and non-routine formulation of verbal questions and providing them to students and avoid direct answer, which enhances their mathematical thinking.
3. Training the students of general education (primary, intermediate, secondary) on the forked thinking during the solution of mathematical problems by putting more than one idea and more than one way to solve it.
4. Train the mathematics teachers in the service training institutions on the skills included in the international project (TIMSS) to keep up with the development and increase the students' achievements.

REFERENCES

[1] Al-Ghamdi, Mona Saad. (2011). The design of a mathematics unit using the method of the six hats of Dibono and testing the higher cognitive processes and the decision-making scale for the third grade students in the Kingdom of Saudi Arabia. Journal of Studies (Educational Sciences). Vol. 38, Supplement 7, pp. 2427-2445.

[2] Diab, Suhail Razak. (2004). Preparation of a proposed unit to teach logic to students in the fifth grade and to measure their effect on their achievement in mathematics. Journal of the Islamic University (series of humanitarian studies). Volume 12, No.2, pp. 233-267.

[3] Debono Center for Teaching Thinking (DCTT) (2015). Introduction to teaching thinking and developing creativity . Author :Amman, Jordan.

[4] Mohammed, Mervat Mahmoud. (2015). Resources for developing mathematics education. Debono Center for Education and Thinking: Amman Jordan.

[5] Shokor, Sundus Nouri. (2016). The impact of a training program based on the mathematical skills included in international tests (TIMSS) in the achievement of middle school students and their appreciation of the scientific value of mathematics. Dissertation thesis unpublished, College of education for pure Sciences (Ibn al-Haytham): University of Baghdad.

[6] Al-Shihri, Manea Bin Ali Al-Haidi. (2017). Analysis of the content of mathematics courses in the intermediate stage by the requirements of the third international study of science and mathematics (TIMSS). International Specialized Educational Journal. Vol. 6. Number 1. pp. 44-64.

[7] Ryan, Adel Attieh. (2015). The extent to which the TIMSS standards are achieved in the mathematics book for the eighth grade students in Palestine. Journal of Educational and Psychological Sciences. Vol. 16. Number 4. pp. 410-439.

[8] Sheikh, Hashim bin Said. (2012). A proposed strategy to improve the level of achievement of Saudi students in mathematics in international competitions (TIMSS). Journal of Studies (Educational Sciences). Vol. 39. Number 1. pp. 33-60.

[9] Al-khatib, Issa Turki. (2017). The degree of inclusion of the requirements of the International Trends in Mathematics and Science (TIMSS-2015) in the content of the eighth grade science book in Jordan. Unpublished Master Thesis, Yarmouk University, Irbid, Jordan.

[10] Abdel Hadi, Bilal. (2013). Bilal Abdel Hadi Blog.,(on line) WWW.bilalabdulhadi.blogs pot.com, Date of entry: 10/25/2015

[11] Mansouri, Meshaal Bader Ahmed. (2017). Effectiveness of the strategies of thinking in the development of the achievement of mathematics for the ninth grade in Kuwait. Journal of Educational Sciences. The third issue. Part (3). pp. 285-311.

[12] Imran, Taghreed. (2001). Towards new horizons of teaching (the end of a century and the ramifications of a new century). Cairo Book House: Cairo.

[13] Al-Saliti, Firas. (2008). Learning and Teaching Strategies - Theory and Practice. World of Modern Books and Wall of the World Book.

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Appendix-1: TIMSS, Trends in International Mathematics and Science Study

Extracted directly from TIMSS website: https://nces.ed.gov/timss/

Overview: The Trends in International Mathematics and Science Study (TIMSS) provides reliable and timely data on the mathematics and science achievement of U.S. students compared to that of students in other countries. TIMSS data have been collected from students at grades 4 and 8 since 1995 every 4 years, generally. In addition, TIMSS Advanced measures advanced mathematics and physics achievement in the final year of secondary school across countries. TIMSS Advanced data have been collected internationally three times, in 1995, 2008 and 2015. The United States participated in TIMSS Advanced in 1995 and 2015. TIMSS is sponsored by the International Association for the Evaluation of Educational Achievement (IEA) and conducted in the United States by the National Center for Education Statistics (NCES).

The most recent TIMSS data collection was in 2015 and included students in grades 4, 8 and 12. Click for further information about TIMSS 2015 and TIMSS Advanced 2015. In TIMSS 2015, more than 60 countries and other education systems, including the United States, participated in TIMSS at grades 4 and 8, and 9 participated in TIMSS Advanced. Results from the 2015 TIMSS and TIMSS Advanced were released on November 29th, and can be viewed on the Results page.

Coming up for TIMSS: TIMSS is in the process of transitioning to a digitally-based assessment called eTIMSS. Beginning in 2019 TIMSS items will be administered via computers or tablets. In addition to items typically found in a paper-and-pencil test, eTIMSS will include new innovative problem solving and inquiry tasks, known as PSIs. These PSIs are designed to simulate real world and laboratory situations where students can integrate and apply process skills and content knowledge to solve mathematics problems and conduct scientific experiments or investigations. The new PSI tasks involve visually attractive, interactive scenarios that present students with adaptive and responsive ways to follow a series of steps toward a solution. About half of the education systems, including the United States, are expected to participate in eTIMSS in the 2019 cycle, while the other half will administer TIMSS in a paper and pencil format as in previous assessments.

Appendix-2: Kuder and Richardson Formula 20

See: http://www.real-statistics.com/reliability/kuder-richardson-formula-20/

The Kuder and Richardson Formula 20 test checks the internal consistency of measurements with dichotomous choices. It is equivalent to performing the split half methodology on all combinations of questions and is applicable when each question is either right or wrong. A correct question scores 1 and an incorrect question scores 0. The test statistic is

Kuder-Richardson formula 20

$$\rho_{KR20} = \frac{k}{k-1}\left(1 - \frac{\sum_{j=1}^{k} p_j q_j}{\sigma^2}\right)$$

Where:

k = number of questions

pj = number of people in the sample who answered question j correctly

qj = number of people in the sample who didn't answer question j correctly

σ2 = variance of the total scores of all the people taking the test = VARP(R1) where R1 = array containing the total scores of all the people taking the test.

Values range from 0 to 1. A high value indicates reliability, while too high a value (in excess of .90) indicates a homogeneous test.

For a good example to illustrate the method refer to the website:
http://www.real-statistics.com/reliability/kuder-richardson-formula-20/