

Identifying Fourth Grade Iranian Students Misconceptions in Measurement and Geometry Based On Timss 2003, 2007, 2011 Results and Suggestions to Prevent and Resolve These Misconceptions

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Abstract

This research aims to Identifying fourth grade Iranian student misconceptions in Measurement and Geometry based on TIMSS 2003, 2007, 2011 results and suggestions to prevent and resolve these misconception by the use of secondary analyzing of the content of the data and asking of Timss 2003-2007- 2011 and the tools teachers use for their questions.

Timss test, as a distinguishing evaluation, is one of the most important studies of International Association for the Evaluation of Educational Achievement, and according to the Timss framework for planning questions in subjective and identifying areas ,and scoring system, codes which are related to misconception are recognized and analyzed. After recognition, some solutions to decrease misconception which will cause to modification, improvement and better usage of mathematics learning process were looked for. In order to collect data of the test and to analyze the content of its questions, Timss international study center is used.

Statical studies of the data shows that misconceptions and conceptual mistakes in measurement and geometry are very common in the fourth grade of school in Iran, to such extend that it reaches 70%. In addition, the findings of this research show that these misconceptions are more or less epidemic.

As a conclusion, research shows that traditional methods of teaching even with careful attention to correctness of the subject and emphasize on repeat and practice, are not able to avoid figuring or stoping of such mathematical misconceptions in students.

This research suggestion is to make a reconsideration in mathematical teaching methods, to pay attention to the the smart meaningful learning, to use efficient new learning tools such as smart boards and computers in order to produce a coherent and related concept in students mind, therefore reduce their misunderstandings in mathematics.

Keywords: comprehension, misconception, mathematics education, timss, measurement, geometry.

Introduction

From the psychological point of view, all students build their own knowledge. Therefore their understanding of a subject or a mathematical concept essentially is not according to teacher's curriculum, and even it might be in contrast with it. Specifically, false impression or half impression of students from a concept, causes systematic mistakes in their works, such impression is called misconception.

Misconceptions can cause confusion and ability to solve mathematical problems successfully. Sometimes, because of complicated nature of connected mathematical concepts,

misconceptions cause difficulty in future learning's of the students. Therefore, identifying, analyzing, and giving solutions for conceptual misconception of student's are essential in different levels of mathematics in order to find why they are produced and how they should be removed which will increase the level of learning.

Mathematics is one of the valuable talents of human culture which has been paid attention as one of the major principle of industrial and technological developments, as it is mentioned in the introduction of Papyrus Raynd (1365 BC), we dare to say, one of the most obvious characteristics of human cognition, which shows the cultural level of that nation, is the

power of deducing, generally this power can be presented in the mathematical skills of that nation. Therefore, we can say, mathematics as a human effort in addition to its various usages, improves the power of deduction and produces thought discipline in the mind. In the present time which the huge growth of technology (owe to mathematics itself) brings huge changes in our mechanical complex life, mathematics opens its place in all the social and industrial cases more and more.

In addition to these, by the advent of the third AD millennium, mathematics as a root for developing of science and technology gets a more principle role in developing and progressing of human life. If you look at the growing process of each application sciences, industry, technology, and every science which is known as the human culture, you'll find an absolute trace of mathematics undoubtedly. The role of mathematics in developing technology, science, and even in some branches of human science, is undeniable.

In the new aims for teaching mathematics which are set for (NCTM, 2000) the emphasis is on the idea that all the students should learn to appreciate mathematics, they should understand the value and usage of mathematics in their process of living and developing of their mind and thought, all the students should be able to make mathematical connections and deduce mathematically in order to gain the ability to solve problems.

One of the basic concepts of mathematics is geometry and measurement. Thought discipline in geometric equations causes the motivation of aesthetics sense, and the logic in the measurement causes the person to have prior thinking skill. The true and deep understanding of the concepts in teaching and learning mathematics is of great value, however, always there is a probability of differences and contrasts between students' understanding of a subject, for example in geometry and measurement, from what teachers consider. This is here which you face the "conceptual errors" of the students. These errors are different from carelessness and lack of concentration which teachers may make. Conceptual errors and mistakes, are not intentional but stems from students false or half understanding, because of this they are called "misconception".

Third International Mathematics and Science Study (TIMSS), One of the most and great adaptive studies in the area of evaluation is educational progress, which is done under supervision of International Association for the Evaluation of Educational Achievement (IEA).

Timss study is performed every four years to investigate the performance of countries attended in teaching of science and mathematics in fourth and eighth grade of elementary school. This study, is one of the greatest and most important studies International Association for the Evaluation of Educational Achievement, which started its formal cooperation in 1991 in Iran. Iran has attended six courses of Timss studies and one course of TIMSS Advanced 2008. In addition, the value of international studies unlike the studies inside the country, shows what it should be or what it may be. International studies of mathematics and science provide an opportunity to investigate unseen elements of school mathematics schedule, because Timss does not provide answers to various questions of educational system of mathematical and science statuses in different countries, but provides windows which we can see our own educational system from an international view point. These data helps us to look at the faults of our educational system which is not never looked before (Peak, 1997).

This article identifies misconceptions of fourth grade Iranian students in Measurement and Geometry based on TIMSS 2003, 2007, 2011, and analyzing secondary content data method, it is a great opportunity for researchers and educational experts to study the connection of students performances in mathematics of elementary school and observe the weak and strong points of educational system from the planning to performance and execution level to find solutions to avoid these misconceptions.

The Aim of the Study

It is not without reason that one of the slogans of "Institute Öntwikkeling Eiskunde Onderwijs" was chosen as the understanding of mathematics rather than skill learning (Frudental, 1980). Therefore, we can conclude that reaching high educational aims, needs producing deep and meaningful mathematics understanding. (Resnick, 1999).

One of the main aims of teaching mathematics is evaluated as helping to the understanding of mathematics rather than learning some disparate do skills, in Japan. They believe that the image Japanese students produce in their mind is deep because of understanding mathematical concepts.

One of the elements which causes serious educational problems in mathematics is the misconceptions of the students because of false extension and generalizing of nets of concepts in the mind, insufficient teaching, informal thinking, reminding of weakness, and making false connections between concepts. Therefore, we can say, misconception is an idea or false impression causes from false understanding of something ".

Misconceptions do not exit independently, it requires special mental frameworks, and changing of students' mental frameworks require removing of misconceptions in mathematics and science. It should be mentioned that by informing the existence of these misconceptions, is not useful, some of these misconception should be interpreted internally by the students believes systems and some of them by their own understandings.(Resnick,1999). Recognizing misconceptions and informing teachers of them, may avoid producing or facing of these misconceptions.

Tools and figures should be introduced correctly in geometry. Correct usage, enough practice, and supplemental evaluation guarantee students familiarity with tools and avoid geometrical misconceptions, knowing students misconceptions can be a useful tool for understanding them(Özerem,2012).

One of the essentials of studying geometry as an important learning components is to let

students analyze and interpret the world we live in and equip them with tools which can be used in mathematics.

Most of the students in measuring with ruler start from one rather than zero and just a few of them understand that they can start from every points on the scale in the condition that they count related intervals unit with the length of the thing.

Timss is a recognition evaluation in teaching mathematics and science of fourth and eighth grade of elementary school which provide valuable information for countries to evaluate and consider how to teach mathematics during the time in these grades. One of the features of Timss is to recognize growing or reduced misunderstandings in teaching from fourth grade and analyzes their reasons.

Timss data provides a good situations for the researchers of attended countries to look over their own mathematical educational statuses in contrast to their own country and other countries. The influence of these data in the mathematical educational searching process, was so significant that impact on all areas of teaching mathematics and related parts, in fact it was the source of motivation in many fields of mathematics and science.

It has been understood from a brief report of Timss test results that the score of Iranian students performance in most of the performed courses of this international study, had been lower than the international average score and during years 2003, 2007, 2011 has not been changed meaningfully (table-1) as it is clear, we can name measurement and geometry that contains 35% of content areas in the fourth grade of elementary school(table- 2).

Table 1

Content areas Fourth grade	percent
Numbers	50
Geometry and measurement	35
Viewing Data	15

Table 2

	Rating Iran in Timss 2003	Rating Iran in Timss 2007	Rating Iran in Timss 2011
Basic lessons	The total number of participating countries	The total number of participating countries	The total number of participating countries

Fourth grade mathematics	$\frac{43}{50}$	$\frac{28}{36}$	$\frac{22}{25}$
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Low average score of Iranian students in fourth grade forced the researchers to recognize the misconceptions of that content area by studying their answers. High percentage of repeated errors in each course especially in measurement and geometry is an evidence to misconceptions in these two courses. By holding this test, on the one hand, it can be an evaluation for regular study of data process to observe educational progress, and on the other hand, it can gain information to make better and more secure policies in educational planning.

Problem

This research focuses on only limited conceptual errors of students which is more concerned about mentioned concepts and processes in discussions of geometry and measurement of Timss three recent courses in fourth grade of elementary school. Therefore, the gained results are limited to the level of generalized mathematical misconceptions of the students. However, according to the Iran integrated educational system and similarity of teaching methods in different levels in other discussions, it can be predicted that the results of this study is applicable to Iran educational system.

Misconception

Perhaps one of the oldest definitions about the word misconception related to Hancoc (1940) who used misconception as " a belief without any bases which doesn't include fear, chance, faith or metaphysics interruption". According to Hancoc, misconception happens because of half and faulty deduction of people. While (Mestre, 1989), believes that some of the attitudes students use to make the world meaningful, are incomplete and faulty facts named "misconception".

However,(Oliver, 1992), defined misconception as some believes and principles in the recognizing structure of a person which are the reasons of advent of systematic conceptual errors. Finally, according to Enkarta online dictionary, misconception is a false idea or attitude of false understanding of something.

Based on the idea that teachers of mathematics in their teaching experience face with lots of students mistakes, it is proper to bring investigatory findings about common misunderstandings in learning mathematics. It causes a clear understanding of misconception for experts and teachers.

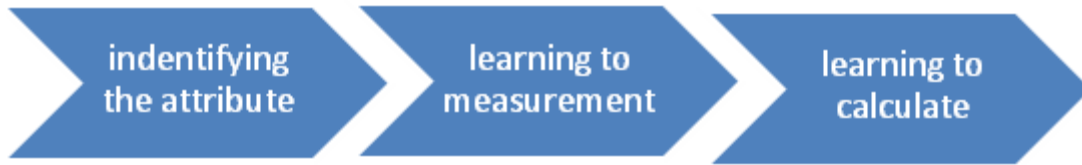
The role of teaching method in recognizing and reducing misconceptions

Mistakes and misconceptions are the results of natural efforts of students to make their own knowledge, so their productions and appearances are not avoidable, we shouldn't look at them as terrible things to remove. Instead, that the best way for paying attention to misconceptions is using them as a part of learning process. Therefore, it is essential to produce an atmosphere to be patient with mistakes and misconceptions of the students in mathematics classes and make use of these misconceptions as opportunities to improve. Smith (1993), in his findings about misconceptions in mathematics and science concluded that by recognizing misconceptions we can identify students uptakes which bring about a systematic model do mistakes.

Measurement and Misconception

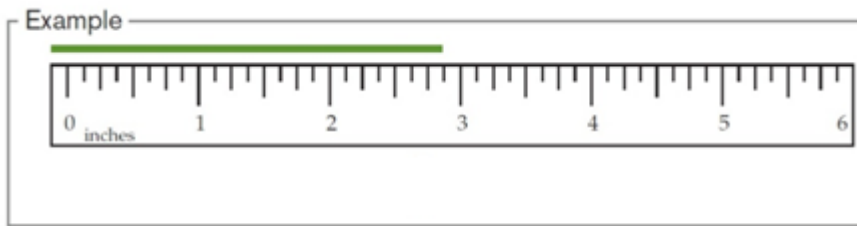
Children measure professionally. This happen every day while they're competing, putting in order or matching something. I can swim across the pool, this is very big for me to move, it doesn't fix in the box, my hand is bigger than yours. Personal experiences like playing with toys, communicating with children, speaking with parents, all can improve initial understanding of things he can measure.

Teaching each of features of measuring things (like length, area, volume, mass, angles) and for events (like time and chance) can be presented in three levels below. (Figure 1-2)



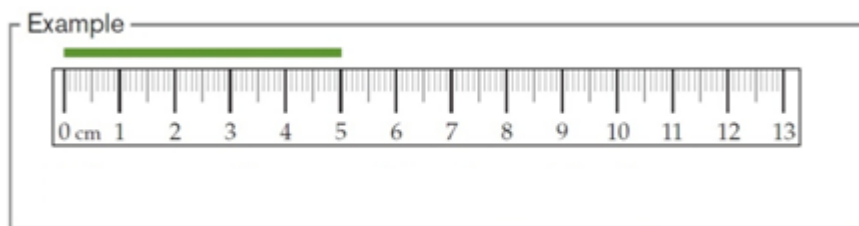
Some of the measurement misconceptions

1-Student begin measuring at the end of the ruler instead of at zero



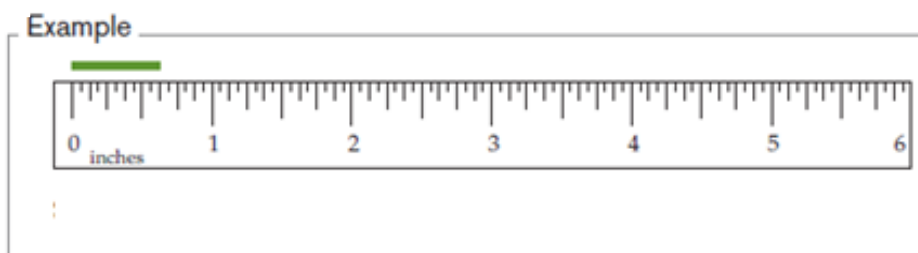
Student response: line segment is $2\frac{7}{8}$ inches in length

2-When measuring at the end of the ruler instead of the spaces



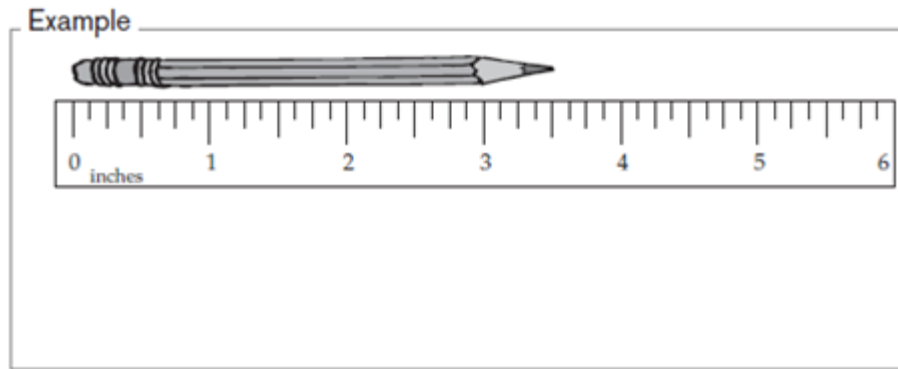
Student response: line segment is 6 centimeters length

3-Students count intervals shown on the ruler as the desired interval regardless of their actual value.



Student response: line segment is $\frac{10}{8}$ inches in length

4-Students fail to interpret interval marks appropriately.



When asked to measure the pencil to the nearest $\frac{1}{8}$ inch, the student responds with $3\frac{3}{8}$ inches or $3\frac{5}{8}$ inches because he fails to interpret the $\frac{1}{2}$ inch mark as a $\frac{1}{8}$ inch mark

In fact, the expression "how long does it take" makes it more difficult to understand the concept of length. There are differences between the length of a straight half line and the distance between two points and the length of a wire between that points when the wire is blended. Children may find them similar at first. Therefore, the distinction between the length of a thing and the distance between two points of that is of importance (Quotes mathematics navigator)

Geometry and Misconception

Learning geometry is not just learning its concepts but having the ability to analyze general features of 2Ds and 3Ds figures and speaking mathematically about geometric relations in order to specialized situations and special connections, transform application, use special deduction drawing, and make geometric models for solving the problems.

Research also shows that children rely on drawing mother rather than theoretical models while they are categorizing and identifying figures. Especially, when a child has both drawing and theoretical definitions of a geometric concept in his mind. Generally, instead of theoretical definition, they recall drawing model. For example children know the definition of parallelograms, most of them rely on drawing model instead of using definition while they are identifying the figures.

Some of the geometry misconceptions

(Quotes mathematics navigator)

Students try to use the formula for finding the perimeter of rectangular shapes on nonrectangular shapes.

Example



Students measure "length" (horizontal distance across) and "width" (vertical distance), then calculates perimeter as $2 \times \text{length} + 2 \times \text{width}$.

Students confuse area and perimeter.

Example

When asked to find the area of a rectangle with dimensions of 12 cm \times 4 cm, students add $12 + 4 + 12 + 4 = 32$ cm.

Example

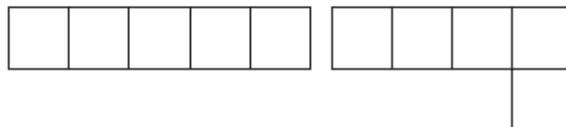
When asked to find the perimeter of a rectangle with dimensions of 8 inches \times 7 inches, students multiply $8 \times 7 = 56$ inches (or square inches).

Example

Students think that perimeter is the sum of the length and the width because area is length times width.

Students think that all shapes with a given perimeter have the same area or that all shapes with a given area have the same perimeter.

Example



Since both of these shapes have an area of 5 square units and a perimeter of 12 units, students conclude that all shapes with an area of 5 square units have a perimeter of 12 units or that all shapes with a perimeter of 12 units have an area of 5 square units.

The framework of educational planning in Timss test

The framework of educational planning in Timss test Generally, Timss test, concentrates on three major principles.

- 1- analyzing educational planning in mathematics and science .
- 2- investigating educational experiences by the use principals and teachers questionnaire data.
- 3-educational progress evaluation of students in mathematics and science .

Providing mathematics framework of educational planning, had been one of the most important steps in Timss test. These frameworks are used as a base for analyzing educational planning in mathematics. In fact, the given framework in Timss test, can be reliable for lots of people and groups who always look for a common point to discuss about their educational plans.

Evolutional framework of fourth grade of elementary school mathematics

Timss mathematics evaluation of fourth grade of elementary school is organized around two areas. First area is the content which presents important areas or subjects evaluated in mathematics. Three contents areas includes numbers, geometric and measurement figures, and presentation of the data. Almost half of the test emphasis on numbers including elementary algebra. The second area, is the recognition which evaluates the thinking process and include knowing, using, and deducing.

Research methodology

Based on the idea that main part of this research focuses on recognizing and describing how misconceptions are and identifying misconceptions in measurement and geometry of fourth grade of elementary school, we can consider it as new studies and searches in teaching by the help of descriptive studies.

Descriptive studies, describe and interpret what is available and notice situation or existing relations, common beliefs, current processes, apparent works, or progressing processes. In such studies, first the present time is noticed while often past events and works which are related to the present time are also of importance.

Because of this, the researcher is interested in criticizing past situation, evaluating present situation and planning and predicting for the future. In order to do the present research, this method is recognized as a suitable one. The aim of this research is based on using Timss data- secondary analysis of Timss content data.

Recognizing scoring system of Timss

Timss scoring guides are planned not only for true and false answers but also for collecting information about the amount of educational progress or identifying educational problem. Students answers can be evidences for the what they know, what they are able to, and what they misunderstand.

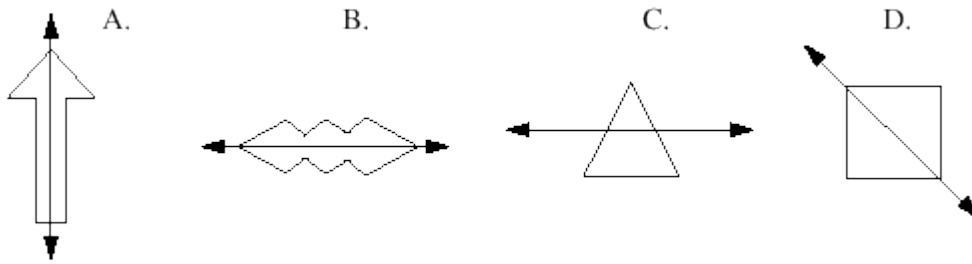
Timss recognition scoring system, uses two digits in every scoring guide which the left side digit shows how correct is the answer. The digit in the right side is used for classifying used method in solving the problem or maybe for tracing usual errors or misconceptions. According to Timss 1990, digits on the left shows incorrect answers by 7 and digits on the right shows correct answers by 1 or 2. If there is an unanswered question it receives 99 code.

The first right digit in coding correct or incorrect answers gives us recognition information (codes 29-70, 29-20, 19-10). Studying these codes can help us to ride the answers to the questions.

analyzing database

Some of the timss tests of geometry and measurement

1- Which of these does not show a line of symmetry?

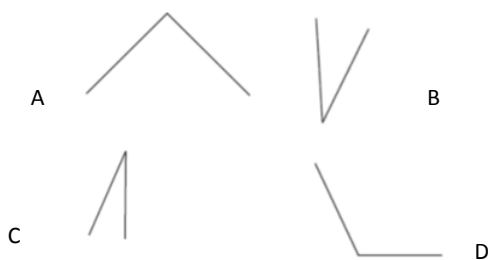


A) B) C) D)

The purpose of the question is to identify the general form of two-dimensional symmetric and asymmetric line. The question is to understand the cognitive domain and the average level is the international standard

The correct answer to this question is "C" Iranian students in understanding the symmetry line in 2011 compared to experimental tests before Iranian students have grown, even at a higher level than the average international level are and Students who have been given the wrong answer to the question of recognition of errors and misconception have line symmetry.

2- Which of the following angles are right angles?



A) B) C) D)

The purpose of the question is to recognize a right angle from multiple angles and knowing the cognitive domain, And the top level is the international standard.

The correct answer to this question is "A", misconception due to incorrect answers to this question can be understood that the student does not understand the concept of a right angle and by defining the right angle is a right angle to detect vision problems or error or That is accustomed to high angle view.

Theoretical framework of analyzing database

Timss is an evaluation in teaching mathematics and science of fourth and eighth grade of elementary school which aim to provide comparative data and information about educational performance of attended countries in order to promote and improve the quality of learning- learned process in mathematics and science. According to the previous studies and evaluations, (IEA) presents its own model of educational planning. In this model, educational planning is looked as the major element of organizing which provides educational opportunities for the students and investigates factors influence these opportunities. This model looks at the educational planning from three perspectives.

1-the intentional educational plan: a plan which is considered by the educational system for students learning

2-performed plan: a plan which is performed in the class is partly under the influence of teachers characteristics, methods of teaching, and educational environment.

3-gained plan: what the students learn and figure their attitudes. According to this model, Timss focuses on describing students learning, educational planning of attended countries, previous related and influential information on students learning.

Mathematics subjective areas in fourth grade in measurement and geometry

Mathematics subjective areas in fourth grade include subject titles which each one points to educational aims mentioned in educational planning of most of the attended countries. This educational aims point to students understandings and capabilities (Özerem,2012).

Table 3 show the list of concepts which should be addressed throughout the curriculum

TOPICS			
MEASURES	ANGLES	TRANSPORTATION	CONSTRUCTION & 3-D SHAPES
Metric measure	Properties of a triangle	Transportation	Constructing triangles 1
Imperial measure	Angles in parallel lines	Combination of Transformation	Constructing triangles 2
Perimeter and area of a rectangle	Properties of a quadrilateral	System	Bisectors
Area of a triangle	Properties of a polygon	Enlargement 1	Constructing perpendiculars
Area of a parallelogram and a trapezium	Congruent shapes		Loci
	3-D Shapes		Surface area of a cuboid
			Volume of a cuboid

Geometric figures and measurement

Figures and measurement areas include attributes and features of figures like length and side, size of the angle, area, and volume. Students should be able to identify lines, angles, and geometric figures (2D and 3D), study their features, and explain them based on geometric relations. This area includes understanding informal coordinate tool, related skills to special visualization, and the relation between two dimensional arrays.

Mathematics recognition areas

In order to answer correctly to Timss questions, students should not only become familiar with evaluated mathematical content, but also they should use series of recognition skills. First area includes knowing facts processes and concepts which students need to know them, while second area- use- focuses on students ability to use their own conceptual knowledge and understanding to solve and answer the problems. In third area- deduce- goes beyond solving ordinary problems and considers unfamiliar situations, formats and complex areas and multi-levels problems.

Data collecting tools for the main study

According to the policies of evaluative international association of educational progress, after performing each course of the test, some of the questions and texts of Timss titled as publishable questions and texts are available for public. This work includes a package of Constructed-Response and Multiple-Choice questions.

Therefore, the researcher use Timss fourth grade question, the percentage of answers of Iranian students and international level in geometry, Timss national studies, fiches of teachers interviews, their experiences about students misconceptions, to find a solution to the problem. One of the other sources of data gathering is interviewing about ten teachers of fourth grade about measurement and geometry discussions to do a more in depth study of the existence of the misconceptions in this discussion in Timss test questions.

Conclusion

The results show that most common reason of Iranian students misconceptions is the students weakness in individual abilities or their level of information. They have mostly problem with recognizing, interpreting, and using scale in measuring. The other one is misconception of recognition and using of measuring units which is twice bigger than the international level. The most common problem in measuring circumference and area is understanding and false using of the formula.

They have had problem with recognizing parts of 3D figures, for example they just pay attention to observable parts and have problem to find the direction in coordinate. When a teacher enters a class with the attitude that his students problem is lack of his ability, he would not feel to study more or change his teaching method, he even doesn't listen to his student deduction to help him and find a solution to his misconceptions.

According to the questions of Timss test, the percentage of Iranian students answers, and the interview of elementary school teachers especially teachers of fourth and fifth grade about the reasons of misconception productions, some of them repeatedly and implicitly said that ministry of education and emphasizing on technics rather than concepts can stop students natural activities in solving the problem and some of them also said that the contrast between intuition and formal education brings about new questions related to mathematics planning in school that according to one of the teachers " higher level students don't know when to use what they know, so they face misconceptions".

In fact, as most of the teachers mentioned, storing information without having the ability to recall them properly means lack of ability of super recognition which is an obstacle to be successful in mathematics and a time to the advent of misconceptions. Imagining the problem in real situations has been welcomed by the teachers, putting the problem in real situation and relating it to the real world is opening a new windows to the students. Therefore, we can say the cause of students problem in answering the Timss questions isn't due to lack of their understanding about mathematical concept of the problem, but most of the time it's because of issues such lack of self-confidence, lack of understanding of the question, person's belief about mathematics, lack of controlling abilities and self discipline and the like which are their main obstacles in answering the questions.

In addition, mathematics which is taught without using proper backgrounds and connection to the real time, stops delivering common sense to real mathematics from learning. This can cause various misconceptions in understanding concepts in mathematics. As a result, it destroys students beliefs to itself as the learners of mathematics and instead it changes their beliefs in such a way that they think of mathematics as an unachievable, unreal, and meaningless creature. All of these factors, can provide a background for mathematical misconception of fourth grade of elementary school in various discussions such as measurement and geometry.

What solutions are there to remove these misconceptions

According to the results of this research, traditional methods of teaching, even if they are done with emphasis and repeated correct way, they won't stop or remove the production of misconceptions. Although teachers know about the presence of misconceptions, they don't have any solutions or they don't do any actions to stop the presence of such problems.

It seems that, first step to face the mathematical misconceptions of the students, is awareness of their presence by the teachers. This awareness which should be considered as professional knowledge of mathematical teachers includes where is the source of these misconceptions and where in mathematical educational plan they may happen more. Then presenting and studying fallacious ideas in the class by using creative solutions as a short time solution can be useful.

Bell(1989), believes that students misconceptions should be studied and investigated even before presenting the correct answer.(Nioton,1997). However, reconsideration of teaching methods from speech methods to cooperative learning, class discussions and group works in such a way that students share more in the process of their own learnings and find an opportunity to plan and evaluate their ideas, can be useful. The cooperation enriches students over recognitions and they can modify them by the reflection of their own ideas.

Table 4 Suggestions
(Quotes Özerem,2012).

Mistake Made Suggestions		Possible Reasons
<p>While the area of the triangles Found the student forget to Divide the number by two Which was on the area Formula.(The area formula of triangle is base times height over two and the student forgot dividing in into two</p>	<ul style="list-style-type: none"> • Just memorized the formula • Cant visualize the image • Lake of reasoning • Few authentic in the primary grades 	<ul style="list-style-type: none"> • More exercises on the topic • Frequent use of image by more interactive teaching • More visual-object use • Deduction of the area Formula in class
<p>Operation mistakes while Finding The student area from the total</p>	<ul style="list-style-type: none"> • Lake of spatial/thinking • Lake of construction idea • Lake of background Education on operation 	<ul style="list-style-type: none"> • More exercise • More home work • Practicing the same Producer on paper to make understanding easier • More practice should be done on operations during primary school
<p>Wrong or missing formula use.(ex: area of parallelograms is base times height. The student divided base times height by two)</p>	<ul style="list-style-type: none"> • Incomplete understanding • No concentration • Not enough practice of the topic 	<ul style="list-style-type: none"> • Computer based teaching can be used to show student the formulae in more fun and colorful way to make them remember easier.

Advices for planners

There are some advices for planners of mathematics in this part

- reconsideration in geometry and measurement teaching method: according to the importance of teaching geometry and measurement, modifying educational planning of mathematics is essential in such a way that it develops students understanding by the help of mathematics and considers its role as a thinking tool,
- paying more attention to enriching abilities of finding model and generalizability of the students: in mathematics tuition program of elementary school less attention is given to the enriching abilities of finding model and generalizability.

Advices for elementary school and mathematics teachers

In this part there are some advices for elementary school and mathematics teacher based on the findings of this research

- developing students understanding of mathematics by connecting proper links to the background knowledge
- paying attention to the misconceptions as a part of learning process is important, it's essential for the teachers to set the atmosphere of the class in such a way that students have a chance to show their misconceptions in order to use them as opportunities to enrich learning process.

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