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Original Article

Assessment of scientific thinking in basic science questions in the Iranian Fourth National Olympiad for medical sciences students

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Abstract

Introduction: Regarding to the importance of students Olympiads, and the need for evaluation of quality of questions, the aim of this study was to analyze questions (indices of difficulty coefficient and discrimination coefficient) of Fourth Olympiad examination among Iranian medical sciences students in the area of scientific thinking in basic science.

Methods: This study was descriptive-analytical study and was conducted in 2013 in the Tabriz University of Medical Sciences (Tabriz, Iran). The individual phase of this period, comprised from four phase and six parts included: designing conceptual map (CM) (three part designing CM, summarizing CM, and designing three questions), hypothesis generating, selecting variables, and analyzing the findings. Data analyzed using descriptive statistics and statistical tests in SPSS for Windows.

Results: According to difficulty coefficient of selecting variable (82%) and making hypothesis was the easiest part (46%). And according to discriminate coefficient, analyzing the findings had the highest discriminate coefficient (83%), and selecting materials had the lowest discriminate coefficient (34%). Difficulty coefficient of the test was estimated about 63%, and discriminate coefficient was 66%. The results of Spearman correlation coefficient test showed that the correlation between scores related to designing CM with generating hypothesis equals to 85%, with selecting variable was 36% and with analyzing the results equals to 71%.

Conclusion: Based on the result of this study, it is necessary for a designer of test to focus on selecting variable part of the test for improvement of quality and validity of the test. Furthermore, regarding to effectiveness of CM, it seems logical to pay more attention to their use.

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Introduction

The main purpose of universities of medical sciences is to educate and to train individuals to assume that they are able to maintain and promote communities health.[1] The role of universities of medical sciences in educating the students is very crucial.[2] Hence now-a-days, most universities are performing their role more effectively than they did in the past the times.[3] Recently, they conduct it by new approach based on the creation of scientific and healthy competitive environment and identification of gifted and high talented students for targeted investment.[4] Organizing scientific Olympiad for university students is one of the most effective strategies, which were emphasized especially in the previous years. Approaches that are particularly relevant to the identification of gifted or highly gifted students are based on the psychometric versus the expert-novice paradigm.[5]

The purpose of conducting Olympiad for university students in our healthy system is to prepare groups of medical sciences students to solve the problems in a competitive environment which it can be effective in maintaining and promoting of communities health. Therefore, efforts to develop problem-solving and reasoning skills, emphasize on critical and creative thinking, focus on health system goals, encourage team work, and interdisciplinary activities are considered as the main objectives of the Olympiad.[6,7]

National Olympiad for medical sciences students is the biggest academic competition for medical sciences students in Iran. According to previous related studies, Olympiads cause to enhancement of self-esteem and confidence of university students and it also help them to select their future job.[8] Olympiads also led to scientific guidance and nurturing talented students,[9] and upgrade of creativity skill, innovation and problem-solving among students.[10] Based on report of the Iranian Ministry of Science website, the academic aims of Olympiads is to identify gifted students in various academic fields, to guide the talented youngsters and help them flourish, to motivate professors, administrators and program planners to reexamine the current educational programs and to improve them, to understand the objectives and acquire necessary information on the level and quality of educational systems, to analyze the data obtained in order to identify the factors influencing the quality of educational systems and to encourage students to follow the best possible academic methods for the acquisition of knowledge.[11]

They also demonstrate the role of teamwork in solving scientific problems, stimulate interactions between students and teachers, and may help improve science education at national and international levels. They make it possible to assess students' ability to analyze and understand different situations and to optimally present their knowledge in a competitive environment. In health system of Iran, the first idea of holding Olympiads appeared in Isfahan University of Medical Sciences in 2000. It was established to evaluate the scientific reasoning in basic science among undergraduate medical students. The first national student scientific Olympiads for undergraduate and Ph.D. students were held in Isfahan University of Medical Sciences in 2009, and the next Olympiads were orderly held in Shiraz and Tehran Universities of Medical Sciences, Iran.[7,12] The Fourth National Scientific Olympiad for medical sciences students was held in the Tabriz University of Medical Sciences, Iran, on February 5 and 6, 2013. This Olympiad like other previous Olympiads comprised of several parts that one of the most important of them was "thinking in basic science" and the subject of this was "biology, pathology, epidemiology, and pharmacology of cancers".[13]

In each training process and particular the exams like scientific Olympiads; quality assessment is necessary and important requirement. Test quality assessment is as important in systematic reviews of diagnostic accuracy studies as it is in any other review. In this regard, test analyzes and questions quality is one of the most important phases of evaluation. In assessing test quality, the questions evaluated one by one for determining their strength and weakness. It causes to determine the weak point and

strength point of quality of exam.[14] Analysis of questions provide an opportunity to evaluate features of each question, and it gives confident that the questions are standard, and they have appropriate quality for assessing expected feature or ability.[15]

Regarding to the importance and place of administrating Olympiads in one hand, and the need to attend to quality of questions and to evaluate students in the other hand (which it has received little attention in previous years), analyzing an evaluating of questions and exams in various areas of Olympiads are necessary and important. Because it can detect existence defects and problems and also, it can improve and solve them. Hence, the present study designed and carried out in order to analyze the question of thinking in basic science in Fourth Olympiad of Tabriz University of Medical Sciences.

Methods

The present study was descriptive-analytical study, which was conducted in Tabriz University of Medical Sciences to assess and to analyze the questions of Fourth Olympiad for medical sciences student in 2013. The exams will be held in 2 days. Three students with highest scores in each domain will be awarded. The Olympiad examinations are usually held annually. This examination conducts in two parts of individual and team work like other fields. Due to time and financial constraints (because of earthquake in Varzeqan, East Azerbaijan), the second part of Olympiad examination, or team work, was not held in this period. And only individual part was held. Therefore, this study was evaluated the questions of first part or individual.

The individual part like other periods included four section and six parts that were explained briefly below, and the information is shown schematically in figure 1.

Section 1: drawing concept map

In this section, students' ability to derive meaning from literature and logical connection between elicited concepts are

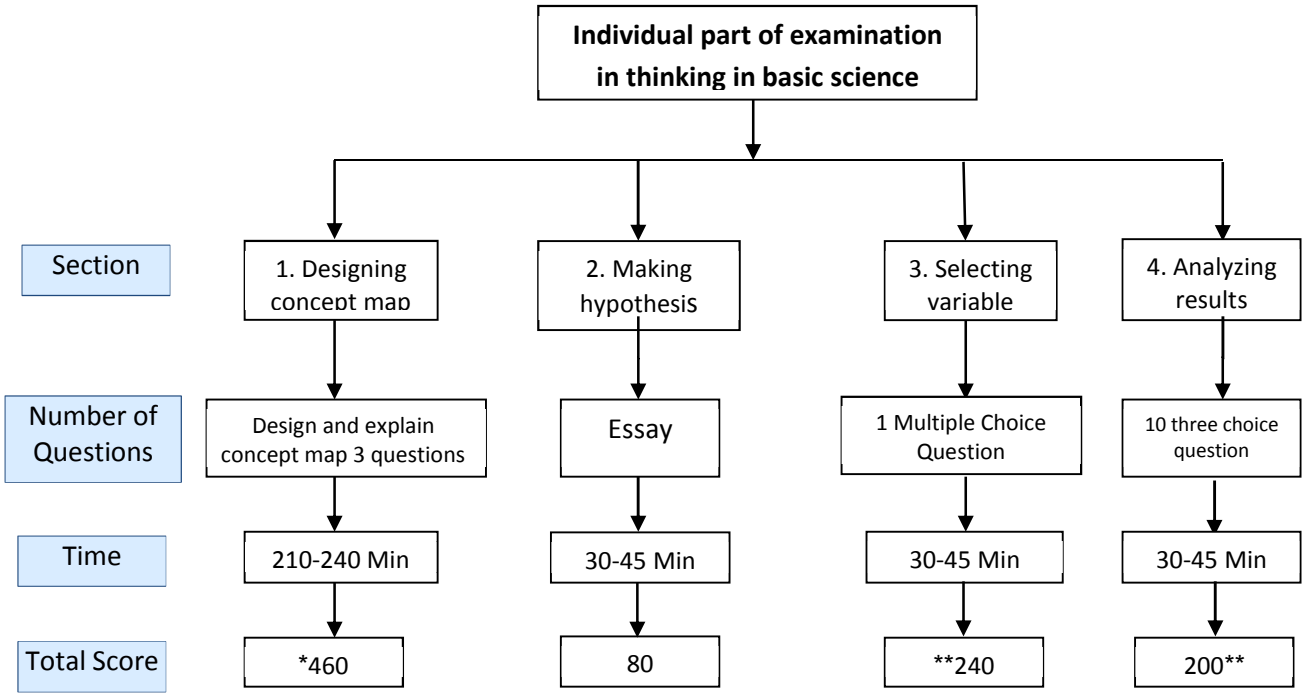

Figure 1. Schematic diagram of individual part of thinking in basic science in Fourth Scientific Olympiad for medical sciences students

* In section of designing concept map, each node and each connection has 10 score. The maximum score was 410 (the standard concept map developed by designer had 21 nodes and 28 connections). In designing question each item had 20 points and explaining concept map had 30 points

** These two sections had two negative points

extracted was evaluated in order to answer to the one question. To this purpose, a scenario in Persian language proposed and three English language papers which were related to the scenario were given to students. They were expected to design a complete concept map in order to answer the question in the scenario. This section is usually the most intensive part of the test, and it allocated the most time of the test (approximately 3½-4 h).

Section 2: hypothesis generating

In this part, series of question assess students' abilities in constructing scientific hypothesis. For do this, results of the test were given to the student and asked them to explain the presented results and make hypothesis with regard to the meaning of the concept map. In this section, if the student makes a hypothesis apart from the test and designers hypothesis, but it is correct and appropriate hypothesis according to designer and scorer, it considered as correct hypothesis and it may be awarded extra points some times.

Section 3

This section evaluates students' abilities' for selecting appropriate variables for accepting and rejecting a specific hypothesis. In this part, a hypothesis related to the subject of the concept map was given to students and asked them to select appropriate variable among the different offered variable with explaining their reason.

Section 4: analyzing results

This section is placed students a summarized of one-hypothesis test study. Student should determine that if the results of the study have advantage or disadvantage for the recommended hypothesis. They use <+> for accepting the hypothesis, <−> for rejecting, and <0> for not accept or not reject of hypothesis.

Item difficulty and item facility

The item difficulty index is one of the most useful, and most frequently reported in the field of item analysis statistics. Perhaps "item difficulty" should have been named "item easiness;" it expresses the proportion or percentage of students who answered the item correctly. Item difficulty can range from 0.0 (none of the students answered the item correctly) to 1.0 (all of the students answered the item correctly). Experts recommend that the average level of difficulty for a four-option multiple choice test should be between 60% and 80%; the average level of difficulty within this range can be obtained, of course, when the difficulty of individual items falls outside of this range. Further insight into the cause of low difficulty value can often be gained by examining the percentage of students who chose each response option.

$$\text{Item difficulty} = 100 \times \frac{\text{Correct choice of high group} + \text{Correct choice of low group}}{\text{Total number of high and low students}}$$

In general, items are having difficulty index values between 0.3 and 0.7 give enough information about differences of participants in tests. For multiple choice questions, the optimal level of item difficulty is slightly less than 1 and it is the level that shows successful guessing. Therefore, in multiple choice questions the optimal level of item difficulty was 0.6. Whatever item difficulty level is greater (close to 100), that question is easier and whenever item difficulty level is smaller (close to 0), the question is a more difficult question.

Item discrimination

The relationship between how well students did on the item and their total exam score. The point-biserial correlation is an index of item discrimination, that is, how well the item serves to discriminate between students with higher and lower levels of knowledge. The point-biserial correlation reflects the degree of relationship between scores on the item 0 = incorrect, item 1 = correct, and total test scores. Thus, the point-biserial will be positive if better students answered the item correctly more frequently than poorer students did, and negative if the opposite occurred. A negative point-biserial is denoted by a minus sign in front of the value.

$$\text{Item dicrimination} = 100 \times \frac{\text{Correct choice of high group} - \text{Correct choice of low group}}{\text{Total number of participated students}}$$

The value of a positive point-biserial discrimination index can range between 0 and 1; the closer the value is to 1, the better the discrimination (the value of a negative point-biserial discrimination index can range between −1 and 0, but positive values are desirable). Item discrimination is greatly influenced by item difficulty. Items with a difficulty of either 0 or 1 will always have a discrimination index of 0, and item discrimination is maximized when item difficulty is close to 0.5. As a general rule, point-biserial values of 0.2 and above are considered to be desirable.

The higher the value, the more discriminating the item. A highly discriminating item indicates that the students who had high exams scores got the item correct, whereas students who had low exam scores got the item incorrect.[16]

When the questions of examination were multiple choices or they were selective, the first quarter and last quarters are regarded as criteria for classifying the question.

Twenty-eight papers related to high scores and 28 papers to the low score were selected (the total number of participants in this field was 114) and item difficulty of each question was calculated. After that their item discrimination was calculated, too.

The important point here in this examination is the comparativeness of students' examination. It means that each respondent's question evaluated according to other students question and scores in comparison of other students. And ultimately 12 of 114 participants were awarded.

The program was written for calculating item difficulty and item discrimination in Excel Microsoft Office Software. It should calculate indices. Afterward, the information of each paper was entered to the designed program in a way that number 1 is allocated for the correct responses, zero for incorrect responses. After calculating item difficulty and item discrimination indices for each question with software, they were evaluated by SPSS for Windows (version 17, SPSS Inc., Chicago, IL, USA) (item discrimination and item difficulty were presented in percentage).

Results

Difficulty coefficient and discrimination coefficient of three fields are shown in table 1. In this section, the highest score which was received by student was 360 and the lowest score which was received by student were 80, and about half of students have earned the top score more than 220. As can be seen in table 1, in the first part of the examination, summarizing concept map section has the highest difficulty coefficient (the easiest section) and the highest difficulty discrimination. Furthermore, designing the question has the lowest difficulty coefficient (the most difficult section) and discrimination coefficient. The concept map, which was designed by question designer, was shown in figure 2.

Table 1. Difficulty and discrimination coefficient of parts of first section (designing concept map) of question of Fourth National Olympiad for medical sciences students around the country about thinking in basic science

Part	Coefficient	
	Discrimination (%)	Difficulty (%)
Designing concept map	74	69
Summarizing concept map	82	78
Designing three questions	64	66

Difficulty coefficient and discrimination coefficient of the second part of the examination (generating hypothesis) were orderly 46% and 74%. Difficulty and discrimination coefficient of the third part are shown in table 2. In this table, the result of one question entitled "selecting one other variable" in raw 18 was shown, too.

The result of table 2 indicated that question 6 was the easiest question in selecting variable part, and questions 1 and 4 were the most difficult questions. Question 7 had the highest discrimination coefficient and question 9 had the lowest discrimination coefficient. A multiple choice question (raw 18) had difficulty coefficient of 81 and discrimination coefficient of 10%, too.

The result of table 3 revealed that question 5 was the easiest question in the analysis of finding and question 9 was the most difficult question. Question 9 had the highest discrimination coefficient and question 8 had

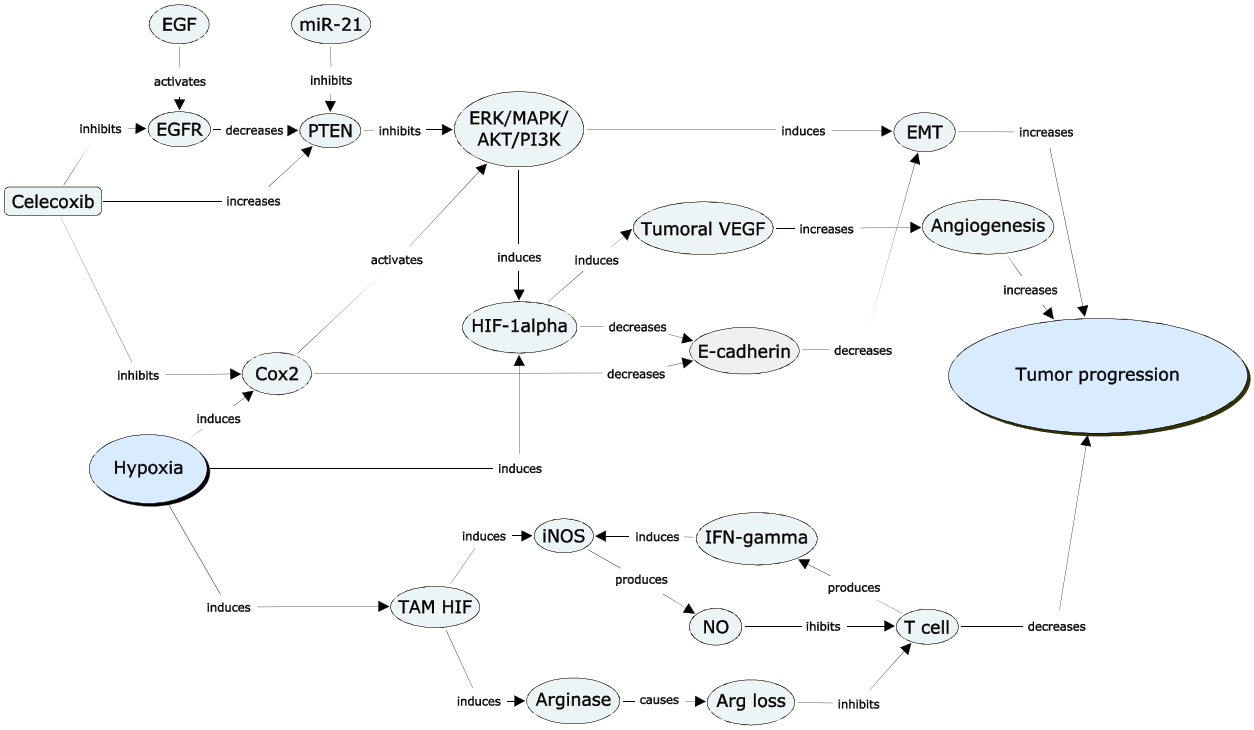

Figure 2. Standard concept map designed by designer of questions of Fourth Scientific Olympiad for medical sciences students

Arg: Arginine; Cox_2: Cyclooxygenase 2; EGF: Epidermal growth factor; EGFR: Epidermal growth factor receptor; EMT: Epithelial-mesenchymal transition; HIF: Hypoxia inducible factor; iNOS: Inducible nitric oxide synthase; miR-21: microRNA-21; NO: Nitric oxide; TAM: Tumor-associated macrophage; VEGF: Vascular endothelial growth factor

Table 2. Discrimination and difficulty coefficient of third part (selecting variable) of thinking in basic sciences of Fourth Scientific Olympiad for medical sciences students around the country

Variable	Difficulty coefficient (%)	Discrimination coefficient (%)
DNA level of iNOS enzyme	32	60
RNA level of iNOS enzyme	75	32
Protein level of eNOS enzyme	52	42
Protein level of iNOS enzyme	32	67
L-arginine tissue level	72	51
Level of the proliferation (in vitro) in tumor infiltrating lymphocytes in response to tumor antigens	81	25
Proliferation level of neoplastic cells	44	66
Apoptosis level of endothelial cells	69	45
Apoptosis level of neoplastic cells	68	14
Angiogenesis and markers level of endothelial	70	20
Tumor size	63	32
Level of local tumor invasiveness	74	31
Level of nitrosylation in extracted proteins from tumor	72	15
Level of gene expression of HIF-1 in tumor tissue	36	34
Evaluating E-cadherin	66	59
Rate of blood flow in tumor tissue	73	51
Level of vascular permeability in tumor tissue	74	30
Selecting one other variable	81	10

iNOS: Inducible nitric oxide synthase; eNOS: Endothelial nitric oxide synthase; HIF: Hypoxia inducible factor

Table 3. Discrimination and difficulty coefficient of forted part (analyzing results) of thinking in basic sciences of Fourth Scientific Olympiad for medical sciences students around the country

Observation	Difficulty coefficient (%)	Discrimination coefficient (%)
Tumor size in group 2 is similar to group 1	34	45
Tumor size decreased in group 4	37	39
Leukocyte proliferation increased in group 2 tumor	42	51
Leukocyte proliferation increased in group 4 tumor	30	62
The use of L-NAME (inhibitor of NO) in group 1 lead to increase in tumor size	51	37
Increase in tumor size in group 3 lead to inhibit L-NAME tumor growth	31	62
WT leukocyte infusion in group 2 increased tumor size	27	53
WT leukocyte infusion in group 3 decreased tumor size	38	35
Prescription of NO precursor in group 3 did not alter tumor growth	26	65
Prescription of NO precursor in group 2 did not affect tumor growth	38	47

L-NAME: NG-nitro-L-arginine methyl ester; NO: Nitric oxide; WT: Wild-Type

the lowest discrimination coefficient.

As it can be seen in figure 1, selecting variable part was the easiest part, and it had lowest discrimination coefficient. There was the highest proportion between difficulty coefficient and discrimination coefficient in designing concept map part. Test difficulty coefficient equal to 63% and discrimination coefficient of test equals to 66%.

Difficulty coefficient and discrimination coefficient of four parts of the examination were shown orderly in figure 3:

- Difficulty coefficient: selecting variable > designing concept map > analysis of findings > hypothesis generating.
- Discrimination coefficient: analysis of findings > designing concept map > hypothesis generating > selecting variable.

The result of Spearman correlation coefficient for evaluating the correlation between acquires scores by participants in a different part of the examination showed that the correlation between acquired scores related to drawing concept map part with hypothesis generating equals to 85%, with selecting variable equal to 36% and with analyzing the findings equal to 71%.

Correlation coefficient between total score and different parts of the examination were shown in table 4.

As it can be seen in table 4, designing concept map had the highest correlation with total scores of examination and against selecting variable had the lowest correlation.

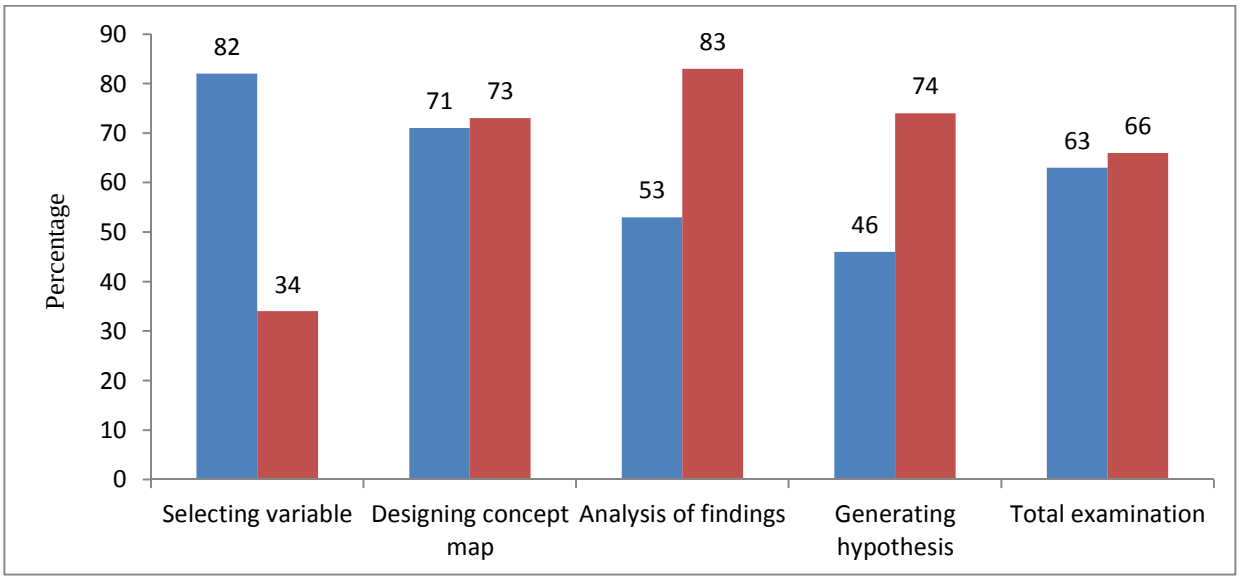

Figure 3. Means of difficulty coefficient and discrimination coefficient of questions in thinking in basic sciences in Fourth Scientific Olympiad medical sciences students around the country

Table 4. Correlation coefficient between total scores and different parts of questions of thinking in basic sciences in Fourth Scientific Olympiad of medical sciences students

Phases	Total score (%)	P
Selecting variables	77	0.002
Generating hypothesis	84	< 0.001
Designing concept map	89	< 0.001
Analyzing results	78	0.035

Discussion

Due to increasing advances in medical sciences and rapid changes in the process of patent's care, there is an urgent need to review the medical education process, qualities and purposes. It seems, inevitable.[17] Universities of medical sciences as authorities of public health had more responsibility for doing this; on the one hand, they should produce required knowledge and technology which was needed for health system, and in other hand they should train and educate the competent human resource for maintaining and promoting of communities health. Therefore, the improved training methods should be considered. One way for developing training methods that aims to promote creative thinking and problem-solving in group in the health system, is to design national competition for talented students like scientific Olympiads.[12]

The results of the present study showed that thinking in basic sciences had appropriate difficulty and discrimination coefficient. In other words, it showed there were high qualities of the question in this examination. Among the different parts of the examination, drawing concept map had the most appropriate difficulty coefficient, and discrimination coefficient and selecting variables had the lowest proportion of difficulty coefficient and discrimination coefficient. Also evaluating correlation among different parts of the examination showed that correlation between designing concept map with generating hypothesis was inappropriate state and with selecting variable was not in the appropriate state. The result of the analysis of thinking in basic sciences questions in the Second Scientific Olympiad for medical sciences students in Shiraz are similar to results of the present study.[18]

It showed that the questions in thinking in basic sciences had appropriate correlation. Contrary to result of this study, which showed that selecting variable had the most inappropriate difficulty coefficient and discrimination coefficient and had the lowest correlation with other parts of examination, analysis of the Second Olympiad in Shiraz showed that analysis of findings had the lowest correlation with mean of students' scores. In the Second Olympiad in Shiraz, selecting variables had not appropriate correlation, too. According to results of two mentioned study, question designer of the examination focus on selecting variable part of the examination for promotion of its quality and validity is inevitable. Perhaps training question designer is an appropriate solution.

Today, with the tremendous growth of technology and large volumes of scientific productions, society need to intelligent, creative and innovative people more than ever. One of the roles of the educational system is to train people that have critical and creative thinking, problem-solving ability, not the ability of accumulation of information and knowledge that they were outdated quickly.[18] Hence, at the present time, we witness of changes in philosophy, content and methods of teaching methods. In new approaches, transferring knowledge from teacher and books to memory, repetition and rewarding replaced with building knowledge though meaningful learning. In this regard, a variety of methods and tools has been used, which one of the most effectiveness and the most important of them was "concept map." Drawing of a concept map was used to evaluate a student's knowledge framework. Concept map is a tool that can represent the knowledge structure by illustrating the relationships between relevant concepts within a given subject domain. By relating and integrating new knowledge with existing knowledge structure, students develop a deeper understanding, allowing better use of knowledge to generate hypotheses, design

experiments, and test the variables to find the answers to scientific questions. Concept maps were developed in 1972 in the course of Novak's research program at Cornell University where he sought to follow and understand changes in children's knowledge of science. It used for the first time as a teaching approach. Concept maps are found to be useful in eliciting knowledge and meaningful learning. Concept maps have strong psychological and epistemological foundations, based on Ausubel's Assimilation Theory and Novak's Theory of Learning, which explain that people learn new things by using their current knowledge and, to a greater or lesser degree, seeking ways to integrate new knowledge and related knowledge already known. When learning meaningfully, the integration of new concepts into our cognitive knowledge structure takes place through linking this new knowledge to concepts we already understand. Thus, a concept map is a graphical representation of these relationships between concepts in our cognitive structure.[19,20] Another important characteristic of concept maps is the inclusion of cross-links. These are relationships or links between concepts in different segments or domains of the concept map. Cross-links help us see how a concept in one domain of knowledge represented on the map is related to a concept in another domain shown on the map.

In the Fourth National Scientific Olympiad about thinking in basic science examination for Iranian medical sciences students, it was expected that students can draw a concept map based on their knowledge and information and also evaluated papers in the examination. Similar to result of Azarpira et al. studies in Shiraz, Iran, this step of the examination had the highest correlation with students' scores and other steps of the examination and also had the most appropriate difficulty and discrimination coefficient.[14] This can be approved the positive effect and effectiveness of using the concept map in evaluating students. As the result of other related studies in different fields of medical sciences that was proved the effect of the concept map in assessing students.[21-27] Therefore, we can use correctly with features and advantages of teaching method based on the concept map in teaching and testing process by encouraging teachers and lectures for application and use of it and also, training university students for promotion of their ability in drawing and using concept maps.

Lack of generalizability of the results and findings to whole tests and student is the weakness of this study. Because the participants of this study were the intelligent and talented students which were selected thorough an internal test, and were entered to national Olympiad. This can affect the result of the study and its generalizability to other students.

Conclusion

Today, the importance and status of scientific Olympiads is obvious. Regarding importance and nature of scientific Olympiads, its' reliability and validity has high importance. Analyzing of questions of the examinations can show its weak and strength point. The result of analyzing thinking in basic sciences questions in Fourth Scientific Olympiad for medical sciences students revealed that the questions had appropriate difficulty and discriminate coefficient. However, there is a need to promote different steps of this examination, especially in "selecting variable," it felt more than other parts. It is hoped that the findings of this study had even small role in the development of questions of this part in next Olympiads.

Conflict of Interests

Authors have no conflict of interest.

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