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Evaluating Functional and Non-Functional Distractors and Their Relationship with Difficulty and Discrimination Indices in Four-Option Multiple-Choice Questions

Abdolhussein Shakurnia, Mehri Ghafourian, Ali Khodadadi, Ata Ghadiri, Afshin Amari, Moosa Shariffat

School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, IRAN

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ABSTRACT

Multiple-choice questions-one best answer (MCQ-OBA) is the most frequently accepted assessment tool in Iran's medical universities. Writing functional distractors (FDs) is an important aspect of framing MCQ-OBA. This study aimed to assess FDs and non-functional distractors (NFDs) in MCQ-OBA and the association of distractor efficiency with difficulty and discrimination indices. This cross-sectional study was conducted at the Department of Immunology, the Ahvaz Jundishapur University of Medical Sciences. A total of 734 MCQ-OBA were reviewed, including 2,936 options (2,202 distractors and 734 correct responses). NFDs were defined as options chosen by <5% of examinees. Of the 734 MCQ-OBAs, 265 (36.1%) had 0 NFDs, 231 (31.5%) had 1 NFD, 146 (19.9%) had 2 NFDs, and 92 (12.5%) had 3 NFDs. The Pearson's correlation showed a significant relationship between the difficulty index and the number of NFDs (r = 0.453; P < 0.0001). However, the correlation between the discrimination index and the number of NFDs was insignificant (r = 0.055; P = 0.135). The findings revealed that NFDs inversely affected the test quality of items. Items with more NFDs were easier and had poorer discriminatory power. The distractor function analysis and revision of NFDs serve as an important method to improve the quality of MCQ-OBA.

Keywords: *Medical education, Multiple-choice question, Functional distractors, Non-functional distractors*

CORRESPONDING AUTHOR

Abdolhussein Shakurnia, Immunology Department, School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

Email: shakurnia@yahoo.com

INTRODUCTION

Assessment is an essential part of the teaching-learning process. It is a dominant motivator that directs, regulates, and drives students' learning (1). Many assessment methods are used to evaluate students' achievement, and multiple-choice questions-one best answer (MCQ-OBA) is the most commonly used method among them to assess basic science knowledge in medical sciences universities. MCQ-OBA has a high degree of objectivity and can cover a considerable amount of content in a short period. However, it is crucial to evaluate MCQ-OBA items to find their effectiveness in assessing students' learning (2–4).

An MCQ-OBA is a question line with several options. The correct option is called the "key," and the other options are described as "distractors." Students who do not know the correct answer are drawn to distractors while other students ignore them (5–6). It is widely accepted that developing a perfect MCQ-OBA is difficult and time-consuming. One reason why some MCQ-OBAs fail might be their lack of effective distractors. Preparing an MCQ-OBA with effective distractors is essential for a valid exam. Therefore, in high-quality MCQ-OBAs, distractor options must also be well-written. Generally, teachers spend much time creating the stem but much less time developing plausible distractor options (7–9). Distractors are the incorrect answer options in MCQ-OBAs. Effective distractors should actually be distracting. They must be similar to the correct option in length, grammar, tense, and complexity and should be on the same continuum. This is required to ensure that examinees cannot use clues to find the correct answer. Low-scoring examinees who have not mastered the content should choose distractors more often, whereas high scorers should do the opposite and choose the correct option (10–12).

After retrieving the basic information about non-functional distractors (NFDs) and functional distractors (FDs), the items were categorised based on the number of NFDs, i.e., 0, 1, 2, and 3. A distractor or distractor efficiency (DE) has the function of distracting students who do not know the correct answer. Students' performance depends upon how distractors are constructed. DE indicates whether the item is well-created or fails to serve its purpose (11).

Item analysis is the act of analysing student responses to exam questions with the intention of evaluating exam quality. Item analysis brings to light test quality regarding item difficulty, item discrimination, and item distractors. This analysis can provide distinct feedback on exam efficacy and support exam design. There is substantial evidence to suggest that across deferent academic disciplines, most MCQ-OBAs used in examinations contain a high proportion of NFDs (4–5).

Writing FDs is an important aspect of framing the quality multiple-choice question. MCQ-OBA with effective distractors is essential for obtaining a valid test. Many studies have been conducted on the MCQ-OBA quality, but only few have dealt with the relationship between NFDs and other parameters of item analysis (13–15). The investigation of NFDs further helps teachers in health-science disciplines to find an optimal number of distractors.The present study was conducted to assess the frequency of FDs and NFDs in MCQ-OBA and the relationship between the number of FDs with difficulty and discrimination indices.

METHODS

This cross-sectional study was conducted at the School of Medicine, the Ahvaz Jundishapur University of Medical Sciences and included immunology course summative examination studies with MCQ-OBA questions from 2017 to 2019. A total of 734 MCQ-OBAs were reviewed, including 2,936 options (2,202 distractors and 734 correct responses). The item analysis parameters used in the current study included the difficulty index (DIF), the discrimination index (DI), and DE. Each test item was analysed for DIF, DI, and DE, by the output of the optical response reader using Question Marks Perception software. Any distractor selected by less than 5% of examinees was considered an NFD (16). DE was calculated based on the number of NFDs per item. Based on the number of NFDs in an MCQ, DE ranges from 0 to 100%. If an MCQ contains three, two, one, or no NFDs, DE will be 0%, 33.3%, 66.6%, and 100%, respectively (12).

DIF defines the percentage of students answering the item correctly and ranges between 0 and 100%. The criteria for DIF are DIF >70 (easy), DIF between 30–70 (acceptable), and DIF <30 (difficult). DI is the ability of an item to distinguish between students of higher and lower capacities and ranges between 0 and 1. The criteria for DI are DI <0.20 (poor), 0.20–0.34 (acceptable), and DI ≥0.35 (excellent) (16).

Data were reported as frequency and mean ± SD for each item. The correlation of the number of NFDs with DIF and DI was determined based on Pearson's correlation coefficient using Statistical Package for Social Sciences (SPSS), version 19 (IBM Corp., Armonk, New York, USA). The linear relationship between DIF and DI was measured using Pearson's correlation test. A p value less than 0.05 was considered statistically significant.

RESULT

In total, 734 MCQ-OBAs with 2,936 options (2,202 distractors and 734 correct responses) were examined. Of the 2,202 distractors, 1,403 (63.71%) were FDs, and 799 (33.29%) were NFDs. The mean and standard deviations of DFI, DI, and DE were 0.58 ± 0.24, 0.24 ± 0.24, and 63.68 ± 34.24, respectively.

The analysis of question performance revealed that across the papers included in this study, the average number of FDs per question (those chosen with a frequency equal to or <5% of the cohort) was 1.91. Of the 734 MCQ-OBAs, 231 (31.5%) had 1 NFD, 146 (19.9%) had 2 NFDs, and 92 (12.5%) had 3 NFDs. Only 265 (36.1%) of the MCQ-OBAs had 3 FDs. Over one-third (33.29%) of the distractors were NFDs, as selected by examinees, and 1,403 distractors (63.71%) were classified as FDs, selected by ≥5% of examinees. A substantial proportion of the distractors were highly implausible (190 = 8.6%), as they were never selected by anyone (Table 1).

Table 2 shows the distribution of DIF and DI in the MCQ-OBAs and their corresponding DE. About half (46.2%) of the MCQ-OBAs were within the acceptable level of difficulty, and over half (58.9%) of them had excellent discrimination indices (DI ≥ 0.20). MCQ-OBAs with an acceptable DIF had the highest DE (79.62%). Also, MCQ-OBAs with an excellent DI had the highest DE (70.45%).

Table 1: Frequency of functional distractors in MCQ-OBA in immunology exams

Number of MCQs	n (%)
MCQ-OBA with 3 functioning distractors (0 NFD, DE =1 00%)	265 (36.1)
MCQ-OBA with 2 functioning distractors (1 NFD, DE = 66.6%)	231 (31.5)
MCQ-OBA with 1 functioning distractor (2NFD, DE = 33.3%)	146 (19.9)
MCQ-OBA s with 0 functioning distractor (NFD, DE = 0)	92 (12.5)

Table 2: Frequency of distractor efficiency in MCQ-OBA with different difficulty and discrimination indices in immunology exams

Index	n (%)	DE % (CI)
DIF		
Difficult (< 0.30)	115 (15.7)	71.86 (65.26–78.47)
Acceptable (0.30–0.70)	339 (46.2)	79.62 (76.97–82.26)
Easy (< 0.70)	280 (38.1)	41.04 (37.39–44.69)
DI		
Poor (< 0.20)	302 (41.1)	57.15 (52.92–61.38)
Acceptable (0.20–0.34)	195 (26.6)	65.61 (61.36–69.85)
Excellent (≥ 0.35)	237 (32.3)	70.43 (66.35–74.52)

One-way ANOVA was used to determine to what extent NFDs contributed to DIF and DI. The analysis was conducted with the independent variable being the number of NFDs and the dependent variable being DIF and DI. The findings showed that DIF was significantly related to the number of NFDs (F = 63.673, $p < 0.001$). Thus, as the number of NFDs increased, the DIF of the items increased, making the test item easier. However, DI was not significantly related to the number of NFDs (F = 1.149, $p < 0.328$). Thus, as the number of NFDs increased, the DI of the items showed no significant changes (Table 3).

A significant positive correlation was observed between DFI and the number of NFDs ($r = 0.453$; $P < 0.0001$). However, DI was not significantly correlated with the number of NFDs ($r = 0.055$; $P = 0.135$).

The relationship between NFDs with DFI and DI is shown in Figure 2. As shown in the figure, the DIF of MCQ-OBA decreased by increasing the number of NFDs. Therefore, easier MCQ-OBAs have more NFDs. Overall, the number of NFDs increases with DIF and decreases with DI.

Figure 1 shows the classification of MCQ-OBAs according to the DIF level with the number of NFDs. Overall, MCQ-OBAs with more NFDs are easier regarding DIF. The DIF of MCQ-OBAs decreases by increasing the number of NFDs.

Table 3: Item difficulty and discriminative as related to number of non-functional distracters

Number of NFDs	0	1	2	3
NFDs per items (number)	265	231	146	92
DFI (mean.SD)	46.25 (19.4)	58.17 (19.9)	70.33 (24.4)	77.38 (29.9)
DI (mean.SD)	25.13 (24.5)	25.35 (23.6)	24.18 (19.9)	20.16 (29.6)

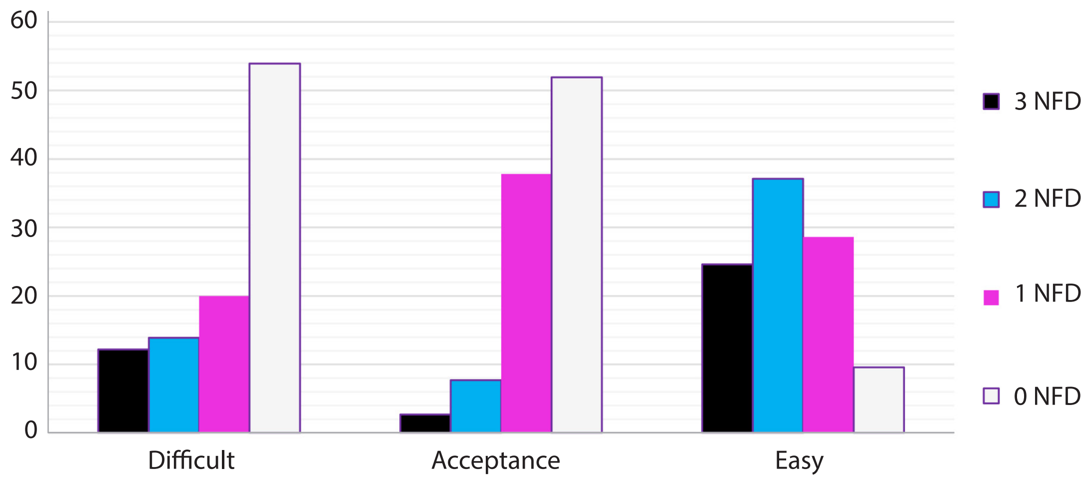

Figure 1: Relationship between number of NFD and difficulty index in immunology exam.

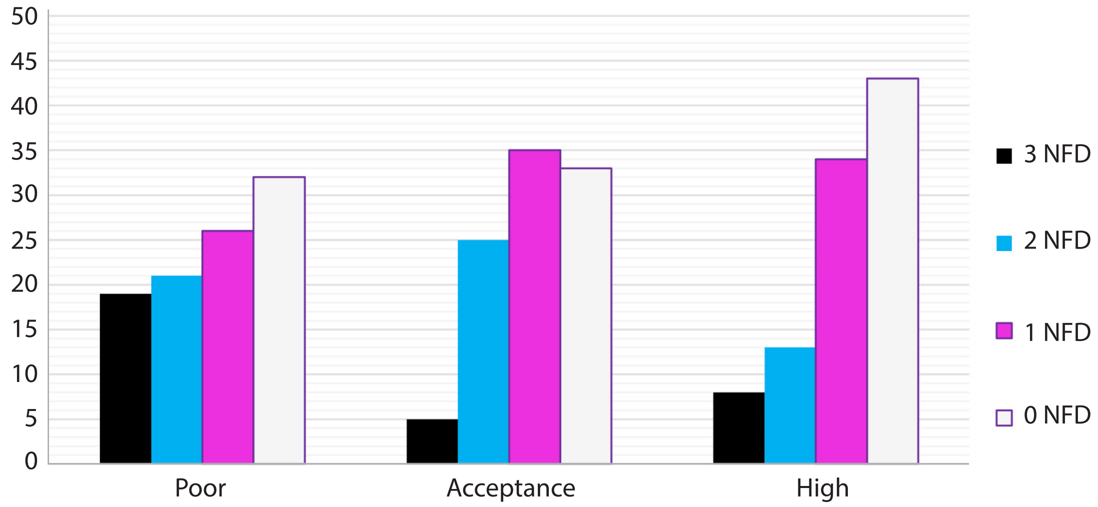

Figure 2: Relationship between number of NFD and DI in immunology exams.

Figure 2 shows the classification of MCQ-OBAs according to the DI level with the number of NFDs. Overall, MCQ-OBAs with more NFDs are weaker regarding DI. The DI of MCQ-OBAs decreases by increasing the number of NFDs.

DISCUSSION

The current study provided valuable insights into FDs and NFDs and their relationship with DIF and DI in MCQ. The results showed that only one-third of the MCQ-OBAs had three FDs, and over half of them had one or two FDs. Tarrant found that approximately two-thirds of all four-option MCQ-OBAs had only one or two FDs (7). Because it is often difficult for teachers to develop three equally plausible distractors, writing plausible distractors and reducing NFDs are essential to creating high-quality MCQ-OBAs. These items may need to be modified if students constantly avoid choosing some distractors.

In the present study, of the 2,202 distractors analysed, 799 (33.29%) were found to be NFDs, and 1,403 (63.71%) were FDs. The findings of this study corroborated those of similar studies. In a study conducted on 514 items and 1,542 distractors, 35.1% were NFDs (7). In another study, 94 (36.15%) were found to be NFDs, and 166 (63.85%) were FDs (17). This may be due to the inability of faculty members to develop MCQ-OBA, especially plausible distractor options. Implementing training courses in MCQ-OBA development for faculty members can help improve MCQ-OBA tests.

Our study showed that the mean DE of the items was 63.68 ± 34.24. This finding is consistent with the study conducted by Mehta and Mokhasi on 150 distractors, which reported a mean DE of 63.97 ± 33.56 (18). The mean DE was also reported as 88.6 ± 18.6 and 83.98 ± 24.52 in studies by Gajjar et al. (19) and Kaur et al. (20), respectively. The findings revealed that items with high NFDs reduced both DE and DFI; thus, such items will be easy for examinees, acting as poor discriminators of academic performance (16–17). Therefore, writing plausible distractors and decreasing NFDs are essential to improve the MCQ-OBA quality.

This study further confirms the consensus in the literature that the degree of non-functionality of distractors influences the psychometric properties of items (21). We found that the number of NFDs was higher in easier items than in difficult ones and was associated with acceptable or excellent

DI. This study's results confirm the results of similar studies by Abdulghani et al. (13) and Mukherjee (22), reporting that the number of NFDs affected the difficulty and discrimination power of an item. Other researchers also reported that increasing the number of NFDs decreased the quality of items (18, 21, 23). Improving the MCQ-OBA quality by training teachers in preparing FDs is recommended.

Our study's results also showed a significant relationship between the number of NFDs and DIF. That is, the number of NFDs can affect the examination quality by decreasing the MCQ difficulty. This finding confirms the results of a similar study by Hingorjo and Jaleel (11), showing that MCQ-OBAs with more NFDs were easier than those with fewer NFDs. Also, Abdulghani et al. (13) showed a significant positive relationship between the number of NFDs and DIF. As a result, the number of NFDs significantly affects the MCQ-OBA difficulty. Implausible distractors and clues to students can affect student performance in MCQ-OBA, making it either more or less difficult to answer items. Nevertheless, this relationship was insignificant regarding DI. Although DI decreased with the increase of NFDs, this decrease was insignificant. No similar study was found to compare the results. Study type, course content, sample size, and students under study may affect this conclusion. Further studies are required to clarify this issue.

Distractors are essential MCQ-OBA components analysed to determine their relative usefulness in any test. Making plausible distractors and decreasing NFDs are necessary to improve the MCQ-OBA quality (24). Therefore, the main rule while framing good MCQ-OBAs is that distractors must be plausible, i.e., closely placed to the correct answer. This will enhance the chance of choosing these distractors over the correct answer by the examinee. This study emphasised the significance of item analysis, including DIF and DI and distractor analysis, which are often overlooked in many such examinations. Items having average difficulty and high discrimination with FDs should be incorporated into exams to improve the validity of examinations.

Constructing a quality MCQ-OBA needs training and experience with timed feedback. The increased number of NFDs indicates the difficulty in developing alternatives by faculty members. This would be reflected in poor test validity. Preparing high-quality MCQ-OBAs is essential to assess student performance accurately. Special training programmes or workshops should be offered to faculty members to hone their skills in constructing high-quality MCQ-OBAs. Further research is recommended to distinguish any future improvements in MCQ-OBA development. Conducting similar studies in other disciplines will also be helpful.

CONCLUSION

MCQ-OBAs with a higher number of NFDs are easier and less discriminatory, and the functionality of distractors affects the MCQ-OBA quality. Thus, NFDs inversely affect the test quality of items. However, items with more FDs are more difficult and have more discriminatory power. The distractor function analysis and revision of NFDs serve as an essential method to improve the MCQ-OBA quality. By analysing the quality of distractors using NFD analysis, item writers can improve the MCQ-OBA quality. This is recommended as an essential quality assurance activity in preparing MCQ-OBA test banks at every department.

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ETHICAL APPROVAL

The Ethics Committee approved this study and allowed access to the examination data (IR.AJUMS.REC.1397.609). The participants' identities were kept anonymous and confidential. No human participants were involved in this study.

REFERENCES

1. Sajjad M, Iltaf S, Khan RA. Nonfunctional distractor analysis: an indicator for quality of multiple choice questions. Pak J Med Sci. 2020;36(5):982. https://doi.org/10.12669/pjms.36.5.2439

2. Shakurnia A, Khosravi A, Mozafari A, Elhampour H. An evaluation of exam questions designed by faculty members, emphasizing on the multiple-choice question structure, Ahvaz Jundishapur University of Medical Sciences, 2007. Strides Dev Med Educ. 2010;6(2):129–38.

3. Kundu S, Ughade JM, Sherke AR, Kanwar Y, Tiwari S, Jatwar R, et al. Impact measurement on medical faculty for adhering to appropriate guidelines in framing effective multiple-choice questions for item analysis. J Med Educ. 2020;19(1):e103482. https://doi.org/10.5812/jme.103482

4. Hassan S, Hod R. Use of item analysis to improve the quality of single best answer multiple choice question in summative assessment of undergraduate medical students in Malaysia. Educ Med J. 2017;9(3):33–43. https://doi.org/10.21315/eimj2017.9.3.4

5. Kheyami D, Jaradat A, Al-Shibani T, Ali FA. Item analysis of multiple-choice questions at the Department of Paediatrics, Arabian Gulf University, Manama, Bahrain. Sultan Qaboos Univ Med J. 2018;18(1):e68–74. https://doi.org/10.18295/squmj.2018.18.01.011

6. Tenzin K, Dorji T, Tenzin T. Construction of multiple-choice questions before and after an educational intervention. J Nepal Med Assoc. 2017;56(205):112–6. https://doi.org/10.31729/jnma.2976

7. Tarrant M, Ware J, Mohammed AM. An assessment of functioning and non-functioning distractors in multiple-choice questions: a descriptive analysis. BMC Med Educ. 2009;9(1):40. https://doi.org/10.1186/1472-6920-9-40

8. Rogausch A, Hofer R, Krebs R. Rarely selected distractors in high stakes medical multiple-choice examinations and their recognition by item authors: a simulation and survey. BMC Med Educ. 2010;10(1):85. https://doi.org/10.1186/1472-6920-10-85

9. Gierl MJ, Bulut O, Guo Q, Zhang X. Developing, analyzing, and using distractors for multiple-choice tests in education: a comprehensive review. Rev Educ Res. 2017;87(6):1082–116. https://doi.org/10.3102/0034654317726529

10. Raymond MR, Stevens C, Bucak SD. The optimal number of options for multiple-choice questions on high-stakes tests: application of a revised index for detecting nonfunctional distractors. Adv Health Sci Educ. 2019;24(1):141–50. https://doi.org/10.1007/s10459-018-9855-9

11. Hingorjo MR, Jaleel F. Analysis of one-best MCQs: the difficulty index, discrimination index and distractor efficiency. J Pak Med Assoc. 2012;62(2):142–7.

12. Ali SH, Carr PA, Ruit KG. Validity and reliability of scores obtained on multiple-choice questions: why functioning distractors matter. J Scholarsh Teach Learn. 2016;16(1):1–14. https://doi.org/10.14434/josotl.v16i1.19106

13. Abdulghani HM, Ahmad F, Ponnamperuma GG, Khalil MS, Aldrees A. The relationship between non-functioning distractors and item difficulty of multiple-choice questions: a descriptive analysis. J Health Spec. 2014;2(4):148–51. https://doi.org/10.4103/1658-600X.142784

14. Ware J, Vik T. Quality assurance of item writing: during the introduction of multiple-choice questions in medicine for high stakes examinations. Med Teach. 2009;31(3):238–43. https://doi.org/10.1080/01421590802155597

15. Ramakrishnan M ABS, Vinayak A. Item analysis: a tool to increase MCQ validity. Indian J Basic Appl Med Res. 2017;6(3):67–71.

16. Namdeo SK, Rout SD. Assessment of functional and non-functional distracter in an item analysis. Int J Contemp Med Res. 2016;7(3):1391–3.

17. Chauhan P, Chauhan G, Chauhan B, Vaza J, Rathod S. Relationship between difficulty index and distracter effectiveness in single best-answer stem type multiple choice questions. Int J Anat Res. 2015;3(4):1607–10. https://doi.org/10.16965/ijar.2015.299

18. Mehta G, Mokhasi V. Item analysis of multiple-choice questions: an assessment of the assessment tool. Int J Health Sci Res. 2014;4(7):197–202.

19. Gajjar S, Sharma R, Kumar P, Rana M. Item and test analysis to identify quality multiple choice questions (MCQs) from an assessment of medical students of Ahmedabad, Gujarat. Indian J Community Med. 2014;39(1):17. https://doi.org/10.4103/0970-0218.126347

20. Kaur M, Singla S, Mahajan R. Item analysis of in use multiple choice questions in pharmacology. Int J Appl Basic Med Res. 2016;6(3):170–3. https://doi.org/10.4103/2229-516X.186965

21. Deepak KK, Al-Umran KU, Al-Sheikh MH, Al-Rubaish A. Psychometrics of multiple-choice questions with non-functioning distracters: implications to medical education. Indian J Physiol Pharmacol. 2015;59(4):428–35.

22. Mukherjee P, Lahiri SK. Analysis of multiple-choice questions (MCQs): Item and test statistics from an assessment in a medical college of Kolkata, West Bengal. IOSR J Dent Med Sci. 2015;1:47–52.

23. Balaha MH. Simplified guidelines for multiple-choice question writing to increase faculty compliance and ensure valid student results. Educ Med J. 2019;11(4):1–17. https://doi.org/10.21315/eimj2019.11.4.1

24. Shakurnia A, Ghafourian M, Khodadadi A, Ghadiri A. Analytical study of quantitative indices of multiple-choice questions of immunology department in Ahvaz Jundishapur University of Medical Sciences. J JundiShapur Educ Dev. 2018;9(2):72–83.