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Evaluation of the relationship between spatial abilities and anatomy learning

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Abstract

Objectives: The aim of this study was to examine the relationship between the spatial abilities of medical school students and their learning in anatomy.

Methods: The spatial abilities of the 120 students (74 females, 46 males) were examined using Mental Rotation Test (MRT). The relationship between the mental rotation scores and the mean scores of their practical and theoretical anatomy examinations was determined in terms of gender.

Results: The study revealed that mental rotation skills of female participants were lower than males; however, there was no significant difference in their exam (theoretical and practical anatomy examinations) scores in terms of gender. The spatial ability of the students had a low level significant effect on their anatomy scores, regarding practical applications.

Conclusion: The results of the study revealed a significant relationship between students' spatial ability and their success in practical anatomy examinations. This suggests that improving spatial ability skills may have a significant contribution to practical anatomy learning and may be considered as a part of anatomy education.

Keywords: anatomy learning; gender; spatial ability

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Introduction

Anatomy education has progressed to a great extent since blackboards were used in classrooms and anatomic drawings were made by hand. With time, the use of two (2D) or three-dimensional (3D) objects representing the geometric structure of the human anatomy became widespread. Researchers on teaching anatomy have revealed that visualization of 2D and 3D materials in anatomy education makes it easier for students to understand the information they have learned and to transform this information to explicit mental images.[1–3] This has increased the significance of spatial abilities in anatomy education.

Spatial thinking ability, which is defined as the ability of creating, retaining, organizing and rotating well-structured visual shapes is among the basic skills required for individuals to sustain their daily lives.[4,5] Researchers argue that spatial ability is an inherent trait and can later be developed through experience just like other abilities such as learning another language.[6,7] The ability to mentally manipulate objects not only has an important place in daily life, but also in the practice of many clinical specialties such as dentistry[7,8] and internal medicine.[9,10] The research studies point out that there is a close relationship between students' mental rotation skills and anatomy learning in medical education.[11–14] This relationship is plausible since anatomy education has a fundamental place in medical education and it is a discipline requiring mental manipulation of visual objects.[15] In anatomy education, it is observed that spatial abilities become prominent while students perform a spatial task. Accordingly, students with high spatial abilities make fewer mistakes and they are more successful in performing this type of actions as opposed to students with low spatial abilities.[7,16]

An examination of systematic review and meta-analysis studies in the literature on spatial abilities in both anatomy education and different disciplines suggests that there is a significant difference in terms of gender.[17] The relationship between skill in gaining theoretical anatomy knowledge and spatial ability was also explored by previous studies.[18–23] These studies put forth that the level of anatomy learning skill of students is directly related with their spatial adaptation skills. The aim of the current study was to identify the level of spatial abilities of medical students in Turkey and reveal its relationship with their progress in learning anatomy. The level of spatial skills of students and progress in learning anatomy are examined in terms of gender.

Materials and Methods

This study was approved by the Social Sciences and Humanities Research Ethics Committee of Necmettin Erbakan University (Approval number: 2016/6) and carried out on 1st grade students attending to Necmettin Erbakan University Meram Medical Faculty during 2017. The data were collected at the end of the first committee in which the students participated in practical anatomy lectures. Mental Rotation Test (MRT) was used to evaluate the spatial ability of the students. Mental rotation ability is based on the ability to mentally rotate two and three dimensional objects quickly and accurately.[24]

MRT is originally developed by Vandenberg and Kuse[25] and adapted to Turkish by Yıldız and Tüzün.[26] This test involves 24 questions. In each question, the students are expected to find the counterparts (2 pieces) of a 3D item that are rotated in different directions and angles (**Figure 1**). The successful application of this action depends on the student's ability to mentally visualize different views of the shapes. When the students mark both shapes correctly, they get 1 point (correct), and when they mark only one correct shape, they get 0 point (wrong). Twenty minutes were allocated to finish this test.

A theoretical examination was applied to the students at the end of the third committee of 1st semester. They were asked to answer 86 questions within 105 minutes. Eleven of these questions included anatomy questions. The questions involved subjects on bones of upper and lower extremity, bones of thoracic cage and vertebral column. The questions were in multiple choice format and the responses were marked on the optical forms. In the practical examination the students were expected to answer 16 questions. In the examination setting, there were eight tables in total and each table included two questions. Students were given 25 seconds for each table and a bell warned the students for the end of the allocated time. On the answer sheet, the students were asked to write the name of the anatomic structure tagged on the bone. The students changed tables when the bell rang and after completing all the tables, the students gave their answer sheet to the instructor. Each correct answer was scored as 0.5 points and the maximum score was 8.

The analyses were performed on the data of the participants who had data for both examinations and had no missing data in the results of MRT. The study was conducted on 120 students (74 females and 46 males). Participants were briefly informed about the study and consent was obtained prior to the study.

Results

The descriptive statistics regarding the MRT scores and practical and theoretical exam scores of the students were shown in **Table 1**. The MRT scores and practical and theoretical exam scores of the according to the gender were shown in **Table 2**.

Table 1

Descriptive statistics of students' anatomy examination and mental rotation test scores.

Score	n	Mean±SD
Theoretical anatomy exam score	120	10.2±1.48
Practical anatomy exam score	120	5.6±1.43
Mental rotation test score	120	15.1±1.38

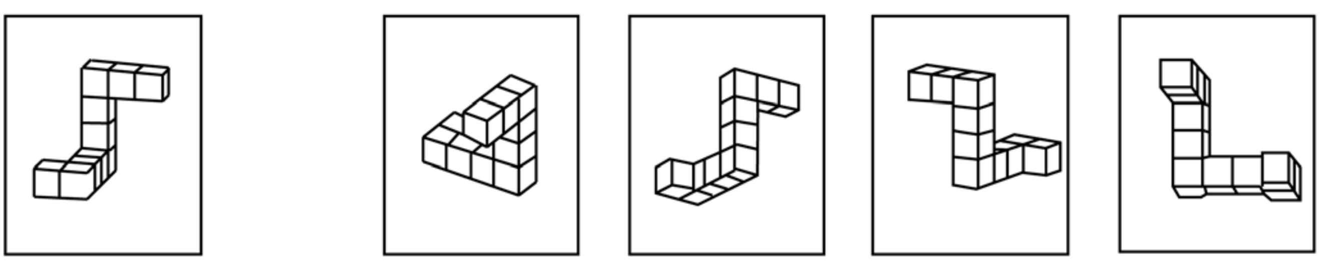

Figure 1. Sample item from the mental rotation test.

Table 2
Examination of students' anatomy and mental rotation test scores according to the gender.

Scores	Gender	n	Mean±SD	t-value	p-value	Effect size
Theoretical anatomy exam score	Female	74	10.1±1.46	-.82	.41	-
	Male	46	10.3±1.52			
Practical anatomy exam score	Female	74	5.5±1.46	-.88	.38	-
	Male	46	5.8±1.38			
Mental rotation test score	Female	74	14.2±3.71	-3.52	.001	0.66
	Male	46	16.6±3.47			

The results showed no statistically significant difference between the females and males regarding their theoretical and practical anatomy exam scores ($p>0.05$). However, the MRT scores of males were significantly higher in males than females ($p<0.05$). Effect size value was also calculated to see the difference clearly and distinctly.[27] Effect size value for the difference in MRT was 0.66 (Cohen's d). Considering the cut-off values of effect size,[27] it can be argued that this difference had a medium level effect. It can be suggested that male students were ahead of female students by 0.66 standard deviation in MRT.

The relationships of the theoretical and practical anatomy exam scores of the students with their MRT scores were evaluated by Pearson correlation test. The results were given in **Table 3**.

The results revealed that there was a medium level (.40) significant relationship between theoretical and practical anatomy scores ($p<0.05$). Besides, there was a low level, but insignificant correlation between theoretical anatomy scores and MRT scores of the students ($p>0.05$). There was a low level significant correlation coefficient between MRT scores and practical anatomy scores (.18) ($p<0.05$). The correlations regarding MRT suggest that evaluations requiring practical applications had a more distinct relationship with mental rotation ability as opposed to theoretical evaluations.

Discussion

The results of the current study revealed that there was a significant difference in the MRT scores of the medical faculty students in terms of gender; however, there was no significant difference in the evaluations with respect to their theoretical anatomy and practical anatomy scores. Gonzales et al.[28] reported that the anatomy scores of the students in pre and post applications didn't show a significant difference in terms of gender. In another study by Sagoo et al.,[29] it was found out that item difficulty had a predictive effect on exam scores of the students. But factors such as gender or the type of the question (whether the questions were asked in a clinical scenario or whether there were visuals in the questions or not) were suggested not to have an effect on the exam scores.[30] Similarly, the effect of gender was not detected in the scores of traditional and online examinations.[31] In limited studies, a significant difference in terms of gender was found in scores of students.[32,33] In these studies, the difference found in

Table 3
The relationships of the students' theoretical and practical anatomy examination scores with their mental rotation test scores by Pearson correlation test.

		Theoretical anatomy exam scores	Practical anatomy exam scores	Mental rotation test scores
Theoretical anatomy scores	Pearson Correlation	1		
	Sig. (2-tailed)	-		
Practical anatomy scores	Pearson Correlation	.397*	1	
	Sig. (2-tailed)	.000	-	
Mental rotation test	Pearson Correlation	.144	.188†	1
	Sig. (2-tailed)	.117	.04	-

*$p<0.01$; †$p<0.05$.

practical applications in favor of women and this was related with the learning strategies that were used by female participants.[19,29,34] Although the difference in terms of gender in learning anatomy is not distinctive to a great extent, it can be suggested that it has a partial effect on the methods chosen by the students. Furthermore, students' approaches to learning were also found to be important in these studies;[35] therefore, individual learning preferences should also be considered rather than addressing solely the differences in terms of gender.

The difference in terms of gender observed in this study with regard to spatial abilities were also observed in various disciplines including cognitive psychology,[36] veterinary medicine,[37] physiology,[38] and anatomy.[14,19,39,40] The variable of gender is also considered as a significant variable to account for the differences in mental rotation skills.[24,39,41,42] In a review examining 40 studies on mental rotation abilities on different disciplines, average effect size regarding gender was calculated as 0.57 (Hedge's g).[20] These results are in line with the effect size regarding gender calculated in the present study. Previous studies report different effect sizes in terms of gender regarding spatial abilities. This difference was attributed to different instruments used in the measurement of spatial skills.[36] In another meta-analysis on the instruments measuring different aspects of spatial skills, a medium level effect in favor of male participants was found.[43]

In an interventional research on spatial abilities in anatomy, although there was a significant increase between pre and post-tests of both (experimental vs control) groups, there was not a significant difference between the mean final scores of both groups regarding spatial abilities. In both groups, it was revealed that the spatial abilities of female participants were significantly lower than males, both before and after the application, and there was not a significant relationship between theoretical anatomy scores and spatial abilities of students in the experimental group.[28] Based on this application, it can be understood that the training for spatial abilities does not make a difference in such a short span of time, and it does not also contribute to scores of exams testing theoretical knowledge. The anatomy course has a structure in which practical applications are at the forefront. In the light of previous studies, it was seen that there was a relationship between MRT and practical examination scores but there was not a significant relationship between MRT and theoretical examination scores.[44] In addition to this, some studies reported no relationship[37,45] or weak relationship[9] between spatial ability of the students and their success in anatomy.

Previous studies suggest that there was a low level relationship between spatial ability and success in anatomy examinations composed of only multiple choice questions but not dissection or practical examinations.[45] However some other studies revealed no relationship between the theoretical anatomy knowledge of the students and their spatial or mental rotation abilities.[11,46] However, Hoyek et al.[2] reported a strong relationship between success in anatomy and spatial abilities of the students. In majority of these studies, there were practical applications. Some of these studies suggested the correlation between practical examination (such as dissection) and mental rotation ability scores of students as the contribution of the practices in anatomy education to mental rotation abilities.[14,47] Still, some other studies interpret this difference in practical applications as the contribution of different mental rotation abilities to learning.[48] In a systematic review, the correlation between the mental rotation abilities of students was noted to be significantly different in comparison with practical and theoretical evaluations.[23] The correlation between mental rotation abilities and practical evaluations was found statistically significant, though at a low level ($r=0.19$, $p<0.05$) in the present study.

Conclusion

The results of the previous studies[2,41,42] and the present study suggest that the spatial abilities of the students are related with their success in learning anatomy, particularly in laboratory practice. This result puts forth that the elements supporting spatial ability of students in practical anatomy education will ease the learning process. Besides, the correlations between traditional practical examinations and online multiple choice examinations showed that these examination methods can be alternative for each other.[33–49] In this respect, it would be appropriate to train spatial abilities of students to increase their success in anatomy practices. Regarding the differences in terms of gender in spatial abilities, use of appropriate learning strategies developed for males and females would be helpful in their learning process.

Conflict of Interest

No conflict of interest was declared by the authors.

Author Contributions

MA: project development, literature review, data collection, data analysis, writing text; MTY: literature review, data collection, writing text; MŞ: final check of the manuscript.

Ethics Approval

This study was approved by the Social Sciences and Humanities Research Ethics Committee of Necmettin Erbakan University (Approval number: 2016/6, Meeting Date: 22/03/2016).

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