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Research Article

The Use of Three-Dimensional Models for the Teaching Anatomical Structures in Biology Courses

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ABSTRACT

The study aimed to evaluate the effects on the success of students in examination by using a three-dimensional plastic model and a three-dimensional digital computer application for the teaching of the subject of "Eye anatomy" under the title of "Sensory organs". The study was conducted on the three groups of high school students (N=43). The groups were split into different laboratories for freelance work. The first group was given standard lecture notes, the second group was given 3D plastic eye models and the third group was given a 3D digital eye model application in their computer environment and they were left to work for equal periods. Pre-test and post-test achievement exams were used as data collection tools to measure the achievement levels of the students on the subject of "Eye anatomy". At the end of this study, no significant difference was found among the groups according to the statistical analysis results. It is assumed that the results may be related to the study habits of the students for the university entrance exam in Turkey; the characteristics of the three-dimensional models used, or the fact that only short-term memory has been tested. So, extensive research is needed to consider these issues.

Keywords: Anatomy, education, three-dimensional model.

Biyoloji Derslerinde Anatomik Yapıların Öğretimi İçin Üç Boyutlu Modellerin Kullanılması

ÖZET

Çalışmada «Duyu organları» başlığı altında «Göz anatomisi» konusunun öğretimi için üç boyutlu plastik model ve üç boyutlu dijital bilgisayar uygulaması kullanılarak öğrencilerin sınav başarısına etkilerinin incelenmesi amaçlanmıştır. Araştırma lise öğrencilerinden oluşan üç grup (N=43) ile yürütülmüştür. Gruplar, serbest çalışma için farklı laboratuvarlara ayrıldı. Birinci gruba standart ders notları, ikinci gruba 3 boyutlu plastik göz modelleri ve üçüncü gruba bilgisayar ortamında 3 boyutlu dijital göz modeli uygulaması verilerek eşit sürelerde çalışmaya bırakılmıştır. Öğrencilerin "Göz anatomisi" konusundaki başarı düzeylerini ölçmek için veri toplama aracı olarak ön test ve son test başarı sınavları kullanılmıştır. Bu çalışma sonunda öğrencilerin sınav başarılarının değerlendirildiği istatistiksel analiz sonuçlarına göre gruplar arasında anlamlı bir farklılık bulunmamıştır. Sonuçların, öğrencilerin Türkiye'deki üniversite giriş sınavına yönelik çalışma alışkanlıkları, kullanılan üç boyutlu modellerin özellikleri veya sadece kısa süreli belleğin test edilmiş olması ile ilgili olabileceği düşünülmektedir. Bu konuları göz önünde bulundurarak gelişmiş araştırmalara da ihtiyaç vardır.

Anahtar sözcükler: Anatomi, eğitim, üç boyutlu model

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Introduction

Learning is expressed as the reception and processing of stimuli through sense organs. Learning style is the characteristic that shows the individual's preferences for learning. Individual variances of learning style are thought to be shaped by the individual's innate differences in perception and thought (Ünal and Kavalcı, 2016). In recent years, the number of studies on the variability in the learning styles of different generations has been quite high. Generation "Z" individuals born in the 2000s and later years are in the middle of rapidly developing technology and live together with it (Akdemir et al., 2013; Toruntay, 2011). This generation carries technology to every stage of life. It has been determined that the generation "Z" individuals use perceptual-intuitive learning styles intensively. Perceptual learners mostly prefer to use their senses, factual information, and sequential information related to real life. Symbols and concepts are interesting, while details are disliked (Ardıç and Altun, 2017). It is seen in studies that linear thinking and learning processes, which are currently dominant in the education system, are not preferred by students (Prensky, 2001; Şahin, 2009). Most students study the subjects only by memorization method in biological education, so they have difficulty making connections between subjects. The results of this situation draw attention when the results of the University Exam in our country are surveyed. It is seen that the average net point of biology is 1.3 in 13 questions (ÖSMY 2022).

Considering these data, the need emerges to associate learning and teaching strategies in the biology curriculum with learning methods unique to generations. It is stated that students have difficulty in understanding, especially because anatomical structures such as the sensory system contain many abstract and complex concepts, and three-dimensional models can facilitate the understanding of such subjects (Düşkün and Ünal, 2016). Anatomy education is the most essential subject in the field of health sciences, and this starts in the pre-university education. Today, studies are showing the coexistence and interaction of biology education at the high school, and university levels and the need for its reorganisation are frequently encountered (Andariana et al., 2020; Caro et al., 2018; Labov et al., 2010; Jensen et al., 2013; Shegog et al., 2012; Taraban et al., 2015). Studies conducted in recent years also show that 3D printers

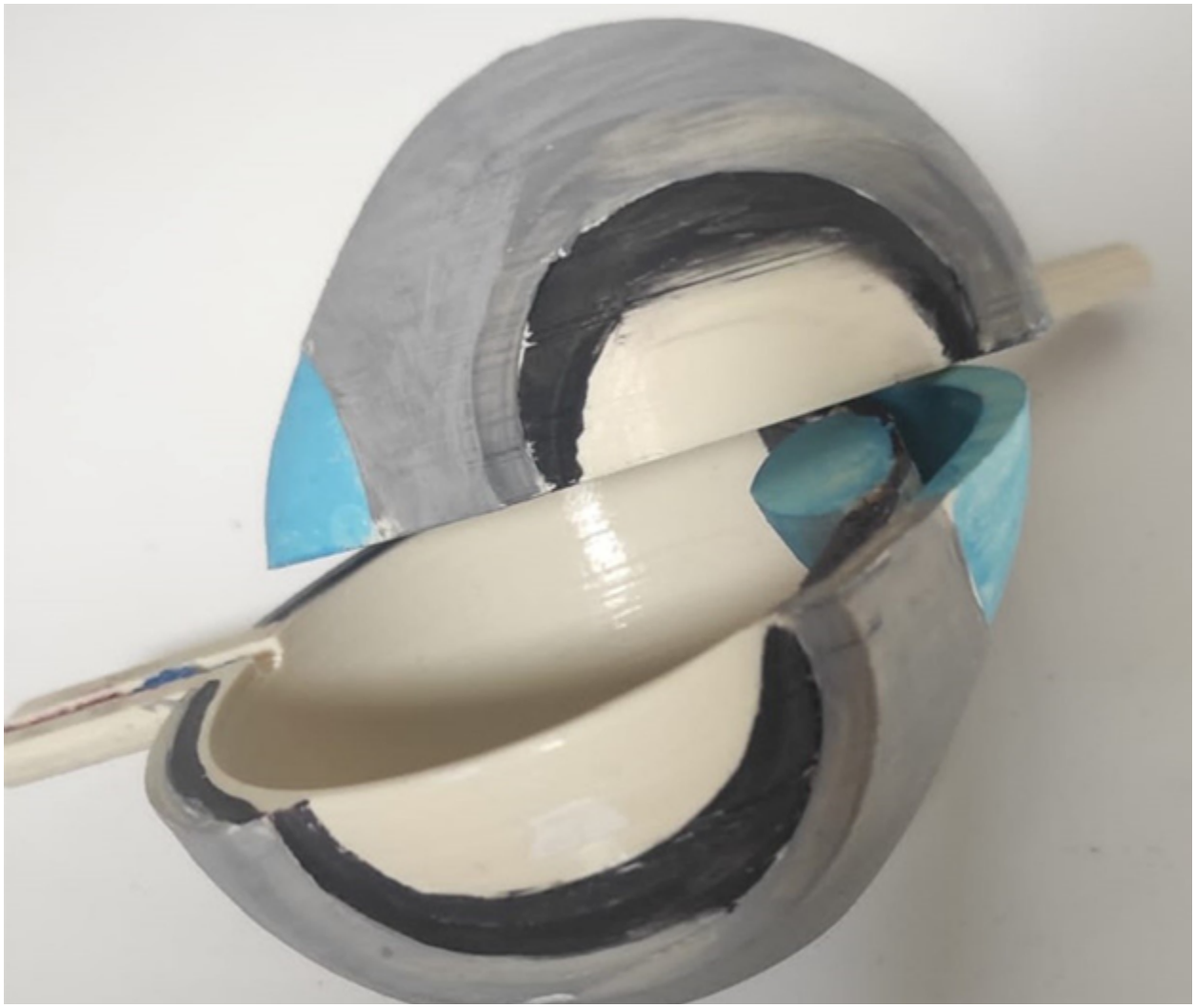

Figure 1. Printed three-dimensional eye model

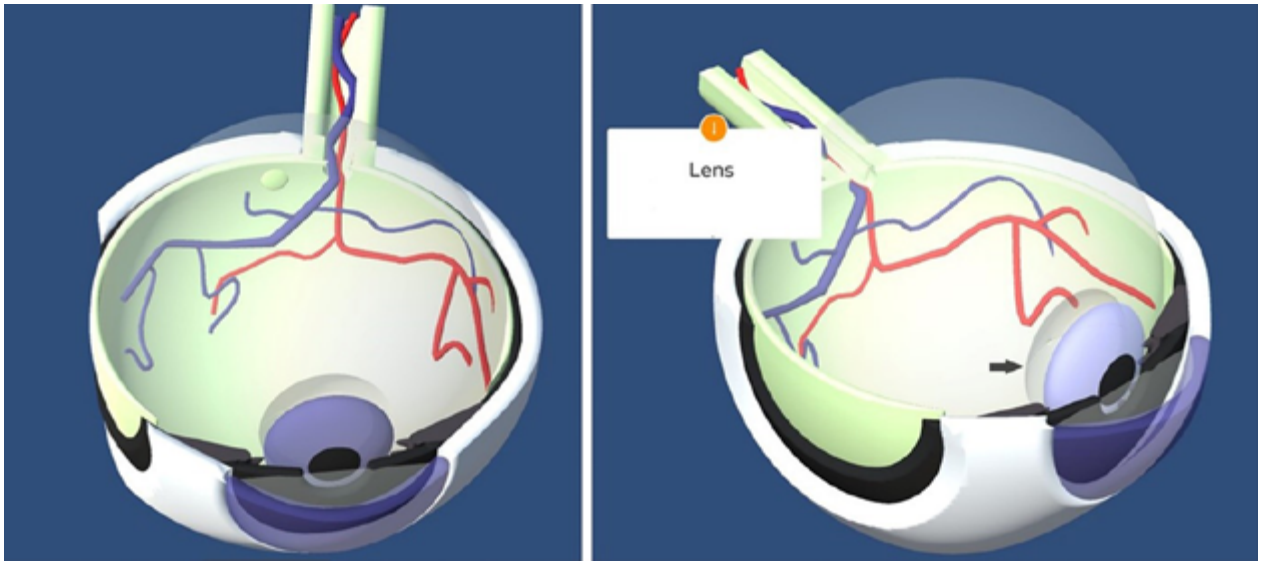

Figure 2. The 3D digital eye model application

are helpful in subjects that students have difficulty in understanding (Bakıcı et al., 2021; Bejdic et al., 2021; Düşkün and Ünal, 2016; Fancovicova and Procop, 2014; Yılgör Huri and Oto, 2022). It is easier to explain complex concepts to students, attract students' attention and participate in the lesson more effectively, and in-class interaction can be easier using 3D technologies, which have many application examples such as the printing of the molecular models in biology (Kökhan and Özcan, 2018). Elangovan et al. (2014) studied with 136 high school students to explain the subject of "cell division" with the classical method and 3D model support in the biology lesson. As a result of the research, they observed that the lesson's success and the percentage of recall were quite advanced in the group using 3D printed models. In addition, the importance of education methods outside the laboratory environment has been more acknowledging, especially during the current COVID-19 pandemic times (Davis and Pinedo, 2021).

This study aimed to observe the effect of using different methods in teaching anatomical subjects in biology lessons on academic achievement. Especially in recent years, the fact that three-dimensional (3D) models have gained an essential place in the education system and students use technology intensively in their daily lives constitutes the basis of this study.

Materials and Methods

A total of 43 high school students divided into three groups, participated in this study. The first group was given standard lecture notes, the second group was assigned 3D plastic eye models and the third group was given a 3D digital eye model application on their computers during their freelance work time. All students were from the same grade, and attention was paid to ensure that the students' academic achievements forming the groups were close to each other.

The digital and solid 3D models were prepared before starting the study. Three-dimensional plastic eye models were designed with a 3D printer. For this purpose, a free-to-use three-dimensional eye model file was saved from the address "https://grabcad.com/". The file was saved in the solid model file format by making some rearrangements in Solidworks and other CAD programs to obtain the same anatomical eye structure and fulfil the requirements of the three-dimensional printer. These files were transferred to a three-dimensional printer (Rigid3D (Sutaş, İzmir, Turkey). A total of 15 three-dimensional eye models were printed. In these models, the parts and layers of the eye were painted with acrylic paint close to the original colours and were made ready for the study (Figure 1). The 3D digital eye model application was prepared by SK to use in the

Table 1. Statistical analysis results of the groups' pre-application (pre-test) and post-application (post-test) exam results

	Classical method (n=15)	3D printing model (n=14)	3D digital model (n=14)	P
The pre-test scores	33.67±14.45	29.14±14.66	35.57±12.40	**0.459**
The post-test scores	59.47±14.92	56.64±15.30	59.29±13.34	**0.960**
P	**0.000**	**0.000**	**0.000**	

* Values are presented as mean value ± standard deviation.
P<0.05: Significant difference between study groups

computer environment. In this application, the 3D model file mentioned above was used. This application was coded using the "Unity 2019.2.1f1" program to work on "Android OS" and "Windows PC" platforms. When the application was launched on any of these platforms, the eyeball model opened in the centre of the screen. The user was able to perform interactively by clicking or touching the model. When the relevant part of the three-dimensional model was touched, the colour of the region changed to (R155 G155 B255), and a popup window opened containing the name of the part and brief information about the part, and zooming-out and rotation were done on the 3D model with "pinch and drag" movements (Figure 2).

Within the scope of the research, it was tried to determine the cause-effect relationships of the variables in different learning environments by making their applications within other groups. In this context, the achievement of the students was assessed with the prepared pre-test and post-test questionnaire. The tests consist of 20 questions, which were parallel to the curriculum and were prepared by taking into account the questions that were already asked in the university exam.

After the study groups were formed, all the students were gathered in the same hall and were informed about the subject. A pre-test was conducted on all the students before undergoing this experimental research process. After this application, while all the students were together, the subject was taught with classical lectures and the question-answer method. The groups were then split into different laboratories for freelance work. One group was given lecture notes, the second group was given plastic eye models, and the third group was given a 3D digital eye model application in the computer system. They were left to work for free for equal periods. After the time was finished, a post-test was applied to all the students at the same time, and the results were subjected to statistical analysis.

Statistical analysis of the results was made using SPSS for Windows program. The normal distribution of the groups' pre-test and post-test success scores was checked with the Shapiro-Wilks test. Since all data showed normal distribution, the subsequent analyses were planned as parametric analyses. First of all, whether there was a significant difference between the groups' academic achievement pre-test and post-test scores was checked with the t-test for dependent variables. A one-way analysis of variance (ANOVA) was used to check whether there was a significant difference between the academic achievement pre-test scores of the groups or not.

Results

The statistical analysis results of the three groups' pre-test and post-test exam results (classical method, 3D eye models and digital 3D computer application) are presented in Table 1.

There are statistically significant increases between the pre-test and post-test scores in all three groups. The pre-test exam scores of the control group students working with the textbook were 33.67, while this value increased to 59.47 after the application. While the average pre-test result of the experimental group of students who made the model work was 29.14, this value became 56.64 after the application. In the experimental group formed by students working with 3D models in the computer environment, these values were 35.57 and 59.29, respectively.

There was no statistical difference between the exam scores of the three groups both before the application (P: 0.459) and after the application (P: 0.960).

Discussion

The study groups must have similar characteristics to compare the educational methods. Attention was paid to ensuring that the academic achievement levels were similar while creating the groups. Thus, no statistical differences were observed between the pre-test exam results of the groups. Therefore, we may accept that the groups were formed as a homogeneous level of attainment. All the students were also informed about the experiment at the same time, and a common pre-course of all groups and a free-study course were applied simultaneously. Thus, according to the study results, the methods used in the formation of all the three groups also had positive effects on learning.

It is generally stated that the use of 3D models is more effective on student achievement than other methods (Elangovan et al., 2014, Park et al., 2019; Şahin, 2009). For this reason, it can be thought that the generation that widely uses digital technology may provide more effective learning through 3D modelling methods. But, there was no statistical difference between the exam scores of the three groups after using the different methods of teaching to learn eye anatomy. The low number of students in the groups may be a factor in why the results were not in the desired direction in this study. On the other hand, the design of the 3D models used in this study may also have affected the study results. The ease of use of the designs cannot be evaluated, either, since no feedback was received on this issue, or the possibility of comparison with different models cannot be found in the study. The possible third factor to take care of is students' study habits with classical methods, especially for exams in our country, which can also be the most critical factor. Park et al. (2019) stated that 82.5% of the students who used a 3D atlas in their studies found 3D atlas easier than a 2D atlas, and 90% of them stated that a 3D atlas is a more understandable-instructional method. However, only 42.5% of these students stated that a 3D atlas could completely replace 2D in the next 10 years (Park et al., 2019), suggesting that there is a more hesitant approach in the transition from classical methods to 3D methods. Fančovičova and Prokop (2014) also offer that alternative methods should not conflict with the traditional methods in anatomy education. Because the result of their study showed that the combination of cadaver dissection with modern innovative methods was more effective for obtaining anatomy knowledge than the use of only one method.

These results may also support the last comments about the results of this study. It may be expected that students will get successful results in test-type exams with the classical course methods that they are accustomed to. For this reason, increasing the number of samples in further studies and repeating the study with more advanced 3D models will contribute to such studies.

It may be accepted that the used pre and post-test exams in this study evaluate short-term learning. Performing permanence tests to evaluate the data that the educational environment created with classical methods and 3D models providing long-term learning may also be effective in detailing such studies. Because it has been reported that it is easier to obtain deep anatomical information, memorise the location of anatomical structures, and quickly identify anatomical structures with 3D methods (Park et al., 2019). Permanently learned information needs less repetition, and time is not lost with constant repetition. It seems possible with the dynamic and interactive environment that 3D models offered to the students may have advanced problem-solving skills and can use what they have learned in practice by realising permanent learning in all areas of educational activities (Ardıç et al., 2017, Park et al., 2019).

Conclusion

In recent years, the number of education method based studies has increased. The comparison of the findings of these studies could be very important in terms of enabling the most effective and efficient ways to be used. According to the results of this study, it can be recommended to expand the number of samples in future studies, re-evaluate the 3D models to be used, and make plans based on the point that permanence tests are effective in determining academic success.

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Conflict of interest

The authors declare that they have no conflict of interest in this study.

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