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DETERMINATION OF STUDENTS' COLOR PREFERENCES IN INTERIOR DESIGN STUDIOS WITH VIRTUAL REALITY (VR) METHOD

SANAL GERÇEKLİK (VR) YÖNTEMİYLE İÇ MEKAN TASARIM STÜDYOLARINDA ÖĞRENCİLERİN RENK TERCİHLERİNİN BELİRLENMESİ

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Abstract
Since the correct use of colors in educational spaces can increase spatial quality and make it possible to achieve quality education, this study investigates the color preferences of students in interior design studios, which is an educational space. The study focused on 198 Interior Architecture undergraduates at Kütahya Dumlupınar University in Turkey during the 2023-2024 fall semester, selected through convenience sampling. In this context, the randomized pretest-posttest control group design, which is a real experimental research model, was used and the participants experienced Munsell colors on the front wall surface of the interior design studio space with the virtual reality method as a stimulus factor. The results of the study revealed that pale blue color (Munsell notation = 5B 6/8) with medium chroma and medium value is the most preferred color in interior design studios and that the experimental process influences color preferences for the space context. However, the general color preferences made without using the spatial context were not affected by the experimental process except for the color orange.

Keywords: Educational Spaces, Design Studios, Interior Color Preferences, Munsell Colors, Immersive Virtual Reality, VR Environment.

Öz
Eğitim mekânlarında renklerin doğru kullanımı mekânsal kaliteyi artırarak kaliteli eğitime ulaşmayı mümkün kılabileceğinden, bu çalışma bir eğitim mekânı olan iç mekân tasarım stüdyolarında öğrencilerin renk tercihlerini araştırmaktadır. Çalışma, 2023-2024 güz döneminde Türkiye'deki Kütahya Dumlupınar Üniversitesi'nde kolayda örnekleme yoluyla seçilen 198 İç Mimarlık lisans öğrencisine odaklanmıştır. Bu kapsamda gerçek deneysel araştırma modeli olan randomize öntest-sontest kontrol gruplu desen kullanılmış ve katılımcılar uyarıcı faktör olarak sanal gerçeklik yöntemi ile iç mimari stüdyo mekânının ön duvar yüzeyinde Munsell renklerini deneyimlemişlerdir. Çalışmanın sonuçları, orta kroma ve orta değere sahip soluk mavi rengin (Munsell notasyonu = 5B 6/8) iç tasarım stüdyolarında en çok tercih edilen renk olduğunu ve deneysel sürecin mekan bağlamına yönelik renk tercihlerini etkilediğini ortaya koymuştur. Bununla birlikte, mekânsal bağlam kullanılmadan yapılan genel renk tercihleri turuncu renk dışında deneysel süreçten etkilenmemiştir.

Anahtar Kelimeler: Eğitim Mekanları, Tasarım Stüdyoları, İç Mekan Renk Tercihleri, Munsell Renkleri, Sürükleyici Sanal Gerçeklik, VR Ortamı.

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INTRODUCTION

The quality of physical infrastructure and the spatial quality of educational environments play a crucial role in achieving Quality Education, alongside the qualifications of educators and the curriculum. Educational institutions should be customized to provide the physical infrastructure, opportunities, and resources for individuals to receive the necessary education at designated times in accordance with their age and situation in the context of human-space interaction. There are many environmental factors for a quality educational space. Baker (1986, p. 80) has divided these factors into three groups: ambient factors such as acoustics, temperature, smell, lighting; social factors such as institutional employees, customers, and users; and design factors such as architecture, texture, material, and color.

It is the design factors that affects the visual perception in space such as color, form, material, light and texture concepts (Aslan et al., 2015, p.139). Visual perception is the most dominant among other types of perception in perceiving space and enables the observer to distinguish the differences between two unstructured fields of view of the same size and shape (Wyszecki & Stiles, 2000, p. 306). In history, people have imitated the colors of fire, water, sky, and soil that they encountered in nature with natural materials collected from nature. During the periods when mostly yellows and reds were imitated, iron-rich colored soils, usage of which goes back to the lower chipped stone period (350000 BC), were used as coloring pigments (Delamare & Guineau, 2012, p. 16). In the following years, the development of the dye industry has facilitated the obtainment of colors and has led to an increase in the number of colors that are limited in the natural environment. The augmenting number and variety of colors has given people the opportunity to choose and prefer among the colors to be used when needed.

Color preferences depend on the sensation and perception of color in the human brain. Color, which is designed in the brain through sensation and perception, is a physical event as it is related to the wavelength of light, a physiological event due to the transformation of light energy coming into the eye into electrical energy in nerve cells such as cone cells, and a psychological event due to the sensation caused by the perception of electrical energy in the brain (Temizsoylu, 1987, p.9). This situation may cause individuals to evaluate colors differently and accordingly, color preferences may vary depending on various factors such as personal characteristics, gender, age-experience, culture-exposed colors and their associations, color characteristics, color knowledge-color education, geographical location, socio-economic status, fashion, social, sociological and historical events, the context in which the color is used, lighting conditions and background colors (Child et al., 1968; Guilford & Smith, 1959; Holmes & Buchanan, 1984; Schloss & Palmer, 2011; Ou et al., 2012). Therefore, these variable factors should be controlled in color preference research.

The first color preference studies were generally conducted by looking at the psychological effects of color samples on subjects by considering colors independently from the interior or any other context (Cohn, 1894; Dorcus, 1926; Washburn, 1911). However interior color preferences are generally related to the action performed in space and the harmony of the color palette used in the space. Considering the existence of many types of spaces along with independent variables such as gender, culture and age that affect color preferences, preference research conducted on colored papers or various color samples may not be usable in the context of space. This situation makes the color preference in the context of space rather important. Color preference studies in the context of space are examined under three headings as physical spaces (Kwallek et al., 1996; Kamaruzzaman et al., 2010; Manav, 2007) virtual spaces (Park & Guerin, 2002; Slatter & Whitfield, 1977; Whitfield, 1984) and virtual reality spaces according to the type of research space.

Virtual reality spaces are interactive environments that are created in three dimensions through computer programs, reflect the real movements of the user simultaneously, and appeal to other senses besides visual sensation (Bayraktar & Kaleli, 2007, p. 2). In virtual reality spaces, the general aim is to create the best representation of reality in the virtual environment and to provide the user with the feeling of reality through mental perception. Virtual reality can be created in two separate ways as immersive virtual reality and non-immersive screen based virtual reality (Robertson et al., 1993, p. 82).

Immersive virtual reality is created with the help of various tools such as data gloves, headsets, virtual reality cabinets, controllers, and virtual reality glasses (VR glasses) used to increase the sense of reality. These tools reinforce human-space interaction and the sense of reality by providing multi-sensory sensations such as visual, auditory, and tactile to virtual reality. VR glasses enable people to participate in events from their own point of view. The sense of movement created by VR glasses with image and sound features and other auxiliary apparatus used in conjunction with it, enables the simultaneous transfer of reality to the virtual environment. It is particularly important to create these visual and auditory elements as close to reality as possible in order to reinforce the experience of space. For this reason, immersive virtual reality space was used in this study.

MATERIAL AND METHODS

In this study, the randomized pretest-posttest control group design was used (Table 1).

Table 1. Research method.

	Group	Pretest	Process	Posttest
198 randomly selected university students	Experiment (100 people)	Color preference survey	Experiencing 24 colors in the context of space with VR glasses	Color preference survey
	Control (98 people)	Color preference survey		Color preference survey

According to the research method, the sample was divided into two groups as experimental and control groups, and the first data on color preferences were collected by applying the same pretest form to both groups. After a certain period of time passed following the pretest phase, only the experimental group was given the opportunity to see and experience 24 colors selected from the Munsell color system on the front wall surface (the wall where the board is located) of the virtual BMA-2 design studio with immersive virtual reality method as a stimulating task. Oculus brand Quest 2 model wireless virtual reality glasses were used in the application and immediately after the application, the color preference results of all subjects in both the experimental and control groups were collected through the same questionnaire used in the pretest phase and the results were compared. No stimulus task or any other procedure was applied to the control group during the experiment. Nevertheless, a post-test was administered to the control group. Thus, it was examined whether there were any changes in the color preferences of the control group during the experiment.

Selection of Subjects

The study population includes all university students studying in interior architecture departments where design education is given. Since it was not possible to reach the entire population, Creswell's (2012, p. 145) convenience sampling method was used. According to this method, the study consists of 198 undergraduate students (n=198) studying at Kütahya Dumlupınar University Department of Interior Architecture in the fall semester of the 2023-2024 academic year, with an average age of 21.08 (between 18-28).

In the pretest phase, 229 people participated in the study, but the measurement results of 25 participants were excluded from the study due to non-data mobility. Later on, 2 students among the participants were disenrolled from the course and 4 students could not be reached either face-to-face [1] or online (e-mail and telephone). For this reason, the data of 6 participants who could not be reached for various reasons were also excluded from the study, and the sample number was finalized with a total of 198 participants, 98 in the control group. In social science research (qualitative, quantitative, experimental), a sample size between 30 and 500 people may be sufficient (Coşkun et al., 2019, p. 162).

[1] Since 8 out of 9 students graduated in the spring term and 1 student could not be reached face-to-face during these periods, the post-test questionnaire application was carried out online via Google form.

Survey Design

In the pretest and posttest stages, the same questionnaire form was used and consists of three parts. The first part of the questionnaire includes demographic characteristics. The second part of the questionnaire includes open-ended questions about BMA-2 interior design studio color preferences, In the third part of the questionnaire, are 5-point Likert-type questions regarding the level of preference of a total of 24 colors in 4 different categories in the color palette. The preference levels for each color are marked as 1-never prefer, 2-do not prefer, 3-undecided (neither prefer nor do not prefer-neutral), 4-prefer, and 5-strongly prefer. This section aims to reveal the importance of the context in which the color is used by comparing the results before and after the experiment.

Colors Used

A virtual color palette of 24 colors was created for use in the experiment. These colors were selected from the Munsell color system. The Munsell color system has proven to be one of the most useful systems in interior design with modifications (Pile, 1997, p. 38). The Munsell color system "offers the best opportunities for quantitative attributes in the direction of qualities familiar to psychologists among systems that purport to represent the full range of colors" (Guilford and Smith, 1959, p. 488). These qualities (feature, scale, dimension) based on human perception are hue, value and chroma, and the 24 colors used in the experiment were defined according to these qualities.

For this purpose, first, six basic color families (red-5R, orange-5YR, yellow-5Y, yellow-5Y, green-5G, blue-5B and purple-5P) were determined in their purest form among Munsell hues in their purest form (the coefficient 5 in the Munsell color system represents the purest form of color hues).The eye perceives the 180 pure shades of color in the spectrum roughly as these six basic colors (Danger, 1987, p. 36). The different colors of these 6 color families in terms of value and chroma were computer generated to obtain bright, pale, light, and dark colors (Figure 1).

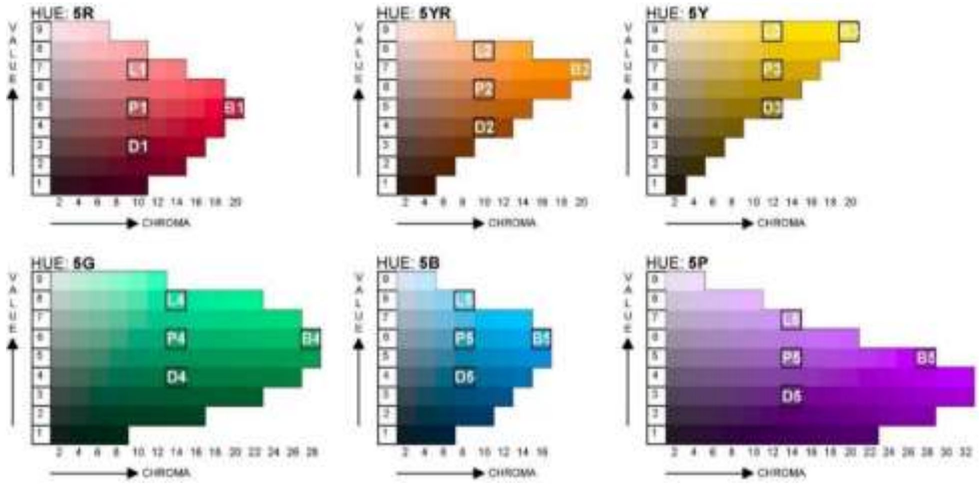

Figure 1. Digitizing the six Munsell surface shades and determining the colors for four different color categories within the scope of the study (Created by the author).

Figure 1 shows the different colors of the red, orange, yellow green, blue, and purple hues in terms of computer-generated value and chroma amount. Among these colors, the basic colors (bright red-B1, bright orange-B2, bright yellow-B3, bright green-B4, bright blue-B5, bright purple-B6) were first determined to be used in the experiment. These colors have medium value and high chroma in each of the 6 color families.The category of pale colors was created with the colors P1 (pale red), P2 (pale orange), P3 (pale yellow), P4 (pale green), P5 (pale blue), and P6 (pale purple), which have approximately the same value as the obtained base colors but whose chroma is almost half of these colors. A light color category and a dark color category were created with reference to the pale colors. Light colors are L1 (light red), L2 (light orange), L3 (light yellow), L4 (light green), L5 (light blue) and L6 (light purple), whose values are 2 steps higher than pale colors. Dark colors are D1 (dark red), D2 (dark orange), D3 (dark yellow), D4 (dark green), D5 (dark blue) and D6 (dark purple), whose values are 2 steps below the pale colors. Thus, a virtual color catalog of 24 Munsell colors obtained from 6 basic color families was completed (Figure 2). The value of the basic colors and pale colors in the color catalog is the same and the chroma is different, and the chroma of the light colors, dark colors, and pale colors is the same and the value is different.

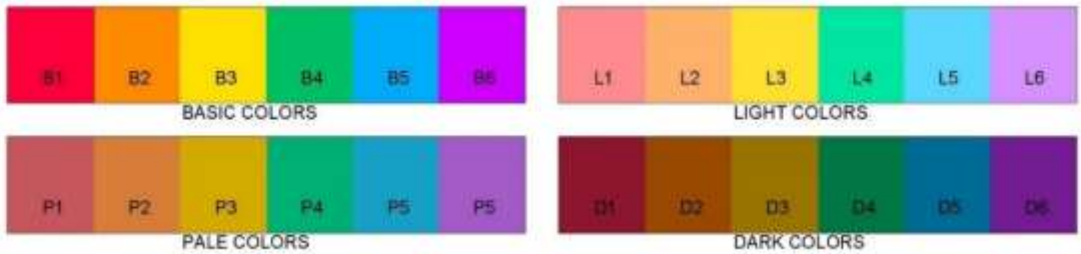

Figure 2. Virtual color palette (Created by the author).

Munsell colors for colored surfaces in Figure 2 were converted into RGB codes to be reproduced in computer environment. However, the conversion process differs due to the color gamut of digital devices. Gamut refers to all the colors that the digital device can produce. All digital devices can produce a limited range of colors depending on their characteristics and the color gamut may vary between devices. This situation shows that Munsell surface colors that are not included in the color gamut of the Toshiba brand P50 A14H model number laptop to be used during the study may not be produced. Therefore, care was taken to ensure that the Munsell surface colors used in the study are within the computer gamut and are convertible for the virtual environment.

To represent the Munsell colors in a virtual environment, the colors were converted into RGB codes using Paul Centore’s conversion tables (2013) and the Color Translator & Analyzer (CTA) program by BabelColor (Centore, 2013, p. 5-26; Pascale, 2022) (Appendix 1).The RGB codes were adjusted to match the color gamut of the Toshiba P50 A14H laptop used in the study, ensuring that all colors were within the device's color range. This process allowed the Munsell colors to be accurately represented in the virtual environment, despite potential variations in digital device color gamuts.

The computerized reproduction of Munsell surface colors with RGB codes using the conversion tables of Centore (2013) prevents color differences in paint pigment materials and difficult to control experimental conditions such as lighting conditions and produces comparable norms for further research. In addition, the research experiment can be repeated by other researchers by extending it to the desired scope and context thanks to the color samples given in RGB and Munsell notation.

Space Used

The physical and virtual spaces for the experiment were both based on the BMA-2 design studio at Kütahya Dumlupınar University Faculty of Architecture. This studio is the most frequently used and familiar space for students, which is expected to save time and yield more accurate results during the study. For the virtual studio, the plan drawings of the physical studio space (Figure 3) were utilized and the method of on-site surveying was used for exact measurements. Then, using AutoCad 2021, 3ds Max 2022 and Unreal Engine 4 programs, a virtual model was created to be one-to-one with the physical space.

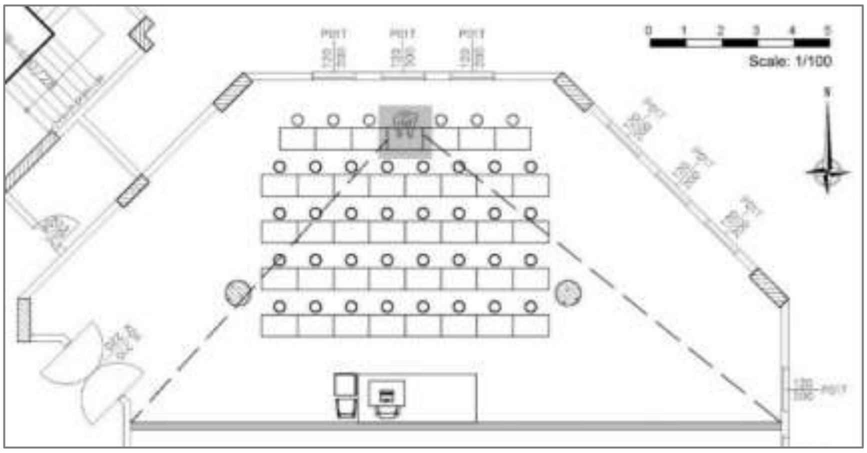

Figure 3. Plan of Kütahya Dumlupınar University Faculty of Architecture BMA- No. 2 Interior Architecture Design Studio (KDPU Department of Building Affairs, 2023).

The BMA-2 studio (157.02 m²) is actively used as a studio as of November 2023, with a ceiling height of 275 cm and a capacity for 40 people. There are white student drawing tables and blue teacher's table and chair in the studio. The walls and ceiling are white, and the floor features light-colored ceramics. Illumination was measured using an Extech 45170 lux meter between 13:00-15:00, when the studio is most active. The illuminance level created by the use of artificial light and natural light together is 434 lux in the measurement carried out under indoor weather conditions in the winter season. Although this level is sufficient for the general illumination of the classroom, it is insufficient for technical drawing works (TS EN 17037). Therefore, in the virtual model, the lighting on the drawing tables (at a height of 73 cm) was adjusted to 750 lux. Additionally, the virtual lighting used a high CRI level for accurate color perception, and the color temperature was set to 5000 K to match the ideal conditions for true color visibility (Fitoz, 2002, p. 93). Daylight was excluded from the virtual environment due to variable conditions.

Procedure

In the randomized pretest-posttest control group design method, all data collection stages were started with the ethics committee approval decision numbered 7 taken at the meeting of Y University[2] Social and Human Sciences Ethics Committee dated 18/10/2023 and numbered 2023/11. After approval was obtained, all participants signed a voluntary consent form and pretest data were collected from these participants between December 27, 2023, and January 15, 2024, entirely face-to-face with the questionnaire method. After the pretest phase was completed, 98 students in the control group were administered the posttest phase between March 4 and March 16, 2024, mostly face-to-face, while 100 students in the experimental group were administered the experiment face-to-face just before the posttest between the same dates (Figure 4).

Figure 4. Experiment application realized in Physical BMA-2 interior design studio (Archive).

[2] University name removed due to double blind policy

Before starting the experiment, the Ishihara color blindness test was applied to the 100 subjects in the experimental group and the subjects who were not color blind were taken to the physical BMA-2 interior architecture design studio. In order to prevent the subjects from being affected by each other, only one subject at a time was taken into the studio and seated in the chair designated for him/her in the classroom. This chair was in the same position both in the physical space and in the virtual reality space. The position of the chair was determined by the subjects as the midpoint of the back row where the wooden wall could be seen from a comfortable and wide angle (see figure 3). The subject seated on the designated chair put on the Oculus Quest 2 headset with the help of the researcher and performed color selection tasks using the Oculus Quest 2 controller, which functioned as a computer mouse.

In the fiction of the virtual space, on the table in front of the subject, the color palette consisting of 24 Munsell colors prepared to be used in the research is located in the form of colored buttons (Figure 5). The subjects are expected to apply these colors to the wall where the whiteboard is located by pressing the buttons and experience them on this wall surface. In this context, the subjects were first asked to apply the 6 colors in the basic color category to the wooden wall surface according to the order in the Munsell color wheel. Then, this method was repeated for the other 3 color categories, and the experiment was concluded after the subjects simultaneously experienced 24 different colors in the virtual color palette on the wooden wall surface in the virtual BMA-2 design studio.

Figure 5. Color palette in the form of colored buttons in the virtual classroom (Created by the author).

EXPERIMENT RESULTS

The pretest and posttest data obtained from all subjects with the questionnaire method were analyzed descriptively with the help of SPSS (Statistical Package for the Social Sciences) data analysis program in line with the research questions and interpreted by checking whether there was a significant difference between the tests. In this study, color preferences constitute the dependent variable, while the context of the interior space in which the color is used constitutes the independent variable.

Research Question-1: How does experiencing colors in the context of space with immersive virtual reality method affect students' color preferences in interior design studios?

In the pretest phase of the study, 11.1% of the participants (n=22) refrained from indicating a color preference for the BMA_2 design studio. The data of 22 participants who did not indicate any color preference were shown as no answer in the statistical analysis phase. The other 176 participants indicated many color types for their studio color preferences, excluding multicolor, vibrant color, light color and dark color. In the posttest phase conducted after the experimental process, none of the participants in both the experimental and control groups selected the option "no answer" for color preference in the context of the space and made at least one-color preference for the BMA_2 design studio space. To perform statistical analysis, the process was simplified by combining similar answers obtained in the pretest and posttest, and categorical data were created (Appendix 2). The answers converted into categorical data were analyzed in terms of experimental and control groups through frequency analysis (Table 2).

Table 2. Color preferences for BMA_2 design studio in the pretest and posttest phase for experimental and control groups

Experimental group pretest			**Experimental group posttest**		
Preferred colors	**n**	**%**	**Preferred colors**	**n**	**%**
White	20	20,0	Blue	31	31,0
Blue	19	19,0	Red	23	23,0
Beige	12	12,0	Orange	20	20,0
No preference	9	9,0	Green	13	13,0
Green	8	8,0	Yellow	6	6,0
Gray	8	8,0	Purple	6	6,0
Yellow	7	7,0	White	1	1,0
Orange	5	5,0	**Total**	**100**	**100,0**
Purple	3	3,0			
Red	2	2,0			
Pink	2	2,0			
Black	1	1,0			
Brown	1	1,0			
Multi Color	1	1,0			
Light Colors	1	1,0			
Vibrant Colors	1	1,0			
Total	**100**	**100,0**			
Control group pretest			**Control group posttest**		
Preferred colors	**n**	**%**	**Preferred colors**	**n**	**%**
Blue	18	18,4	White	23	23,5
Beige	14	14,3	Blue	21	21,4
White	13	13,3	Beige	14	14,3
Gray	13	13,3	Green	10	10,2
No preference	13	13,3	Gray	7	7,1
Green	10	10,2	Orange	5	5,1
Red	3	3,1	Multi Color	5	5,1
Orange	3	3,1	Purple	4	4,1
Black	3	3,1	Yellow	2	2,0
Multi Color	3	3,1	Black	2	2,0
Yellow	2	2,0	Light Colors	2	2,0
Purple	1	1,0	Red	1	1,0
Brown	1	1,0	Brown	1	1,0
Dark Colors	1	1,0	Navy Blue	1	1,0
Total	**98**	**100,0**	**Total**	**98**	**100,0**

n= Frequency %= Percentage

Table 2 shows the pretest and posttest color preferences of the control and experimental groups for the BMA-2 design studio space. As can be seen, blue color and its shades were the most preferred color for the BMA_2 design studio both in the pretest and posttest phase among all participants. In the pretest, a total of 37 students preferred blue as the main color for the BMA_2 design studio. After blue, white was the most preferred color for the studio space. A total of 33 students expressed their satisfaction with the current color of the BMA_2 design studio and preferred white again. After that, beige, gray and green were the preferred colors for the studio respectively.

When the pretest-posttest preference results in Table 2 are compared in terms of groups, it is seen that experiencing colors with VR glasses is effective on color preferences for the space. The colors red and orange, which were preferred by a total of 7 people from the experimental group for the BMA-2 design studio before the experiment, were preferred by 43 people after the experiment. The preference for blue color, which was preferred by a total of 19 subjects, increased to 31. While blue color was associated with concepts such as creativity, tranquility and inspiration by the experimental group, red and orange colors were preferred because they were associated with energy, vitality, warmth and attracting attention. Pale blue (5B 6/8) was the most preferred among blue color tones whereas dark red (5R 3/10) was the most preferred one among the red color tones and light orange (5YR 8/10) among the orange color tones.

Among all participants, white, the existing color of the BMA-2 design studio, was preferred immediately after the universally liked blue color in the pretest phase. In other words, when different colors are not experienced in the context of the space, the color preferences for the space are affected by the existing colors of the space. However, the preference for white, the existing color of the space, was almost completely abandoned by 100 participants who experienced different colors through VR glasses in the design studio space. Only 1 participant from the experimental group still preferred white despite the colors experienced.

After the experimental process, the preference for blue color increased among the experimental group and exciting chromatic colors such as red and orange became the most preferred colors for design studio interiors, unlike white color. In this case, it was seen that the white color, which was considered very suitable for studio spaces by the participants before the experiment, was preferred only out of habit, and when compared to different colors, more dynamic and activating colors were preferred for studio interiors compared to white.

Research Question-2: Is there a significant difference between the pretest and posttest scores of the students in the experimental and control groups regarding their general color preferences? In other words, does experiencing colors through VR glasses have an effect on general color preferences?

General color preferences were measured on a 5-point Likert scale. The mean pretest and posttest preference scores of all participants for 24 colors on a 5-point Likert scale were tabulated (Table 3).

Table 3. Frequency analysis of 24 different colors.

Preference queue	Posttest (n=198)			Pretest (n=198)		
	All Colors	$\bar{x}$	S_x	**All Colors**	$\bar{x}$	S_x
1	Blue	4,11	0,81	Blue	4,15	0,89
2	Light Blue	4,09	0,79	Light Blue	4,09	0,95
3	Dark Blue	3,97	0,93	Dark Blue	3,86	1,14
4	Pale Blue	3,62	0,95	Pale Blue	3,76	1,03
5	Light Green	3,56	0,99	Light Green	3,57	1,08
6	Green	3,55	1,08	Green	3,54	1,13
7	Dark Green	3,52	1,18	Light Purple	3,49	1,23
8	Dark Red	3,32	1,29	Dark Green	3,44	1,24
9	Light Purple	3,26	1,24	Dark Red	3,34	1,25
10	Pale Green	3,25	1,09	Dark Purple	3,29	1,29
11	Dark Purple	3,23	1,30	Pale Green	3,28	1,12
12	Red	3,18	1,14	Purple	3,25	1,25
13	Purple	3,09	1,27	Pale Purple	3,20	1,19
14	Light Red	3,07	1,07	Red	3,17	1,15
15	Orange	3,06	1,00	Light Orange	3,02	1,09
16	Light Orange	3,04	1,07	Orange	2,97	1,00
17	Pale Purple	3,01	1,15	Light Yellow	2,96	1,20
18	Light Yellow	2,99	1,16	Pale Red	2,94	1,18
19	Pale Red	2,90	1,13	Light Red	2,93	1,05
20	Yellow	2,90	1,01	Yellow	2,86	1,03
21	Dark Orange	2,85	1,12	Dark Orange	2,84	1,15
22	Pale Orange	2,76	1,10	Pale Orange	2,79	1,04
23	Pale Yellow	2,75	1,11	Pale Yellow	2,72	1,21
24	Dark Yellow	2,72	1,11	Dark Yellow	2,59	1,15

n= number of participants, $\bar{x}$=mean, $S_{x=}$ standard deviation

Examining Table 3, it is seen that among the context-free color preferences of all participants, all shades of blue were the most preferred colors in both the pretest and posttest stages whereas the 5 colors least preferred by all participants in both the pretest and posttest phases were the dark and pale shades of yellow and orange.

The pretest mean scores of the experimental and control groups for the 24 colors in the 5-point Likert scale were compared by independent sample t-test, but no statistically significant difference was found ($p>0.05$, t values are given in Appendix 3). This supports that the pretest mean scores for general color preference for both groups were not statistically significantly different from each other and that the groups were in equal conditions at the beginning of the study. To determine the effect of the experimental procedure in the control and experimental groups, which were supported to start the study under equal conditions by measuring the same pretest scores, the mean difference between the posttest and pretest scores was first calculated. Then, whether there was a statistically significant difference between the difference scores obtained for the control and experimental groups was tested with an independent sample t-test (Appendix 4). As a result of the independent sample t-test, no statistically significant difference was found between the difference scores of the experimental and control groups in general ($p>0.05$, t values are given in Appendix 4). This supports that the posttest-pretest difference averages of the control and experimental groups were statistically similar. Among a total of 24 different colors, only the difference between the posttest and pretest for the pale orange color was statistically significant between the experimental and control groups ($p<0.05$, $t=2.040$), which was in favor of the experimental group. It can be stated that experiencing the color orange through VR glasses caused positive preferences for the said color. The color preferences indicate general preferences and do not include a spatial context. Therefore, it can be said that experiencing colors does not have a great effect on general color preferences made without the use of spatial context.

CONCLUSION

This study was carried out with the main purpose of determining the color preferences that can be effective in achieving quality learning in interior design studio spaces and the results obtained can be used in different scientific studies. For this purpose, a two-stage color preference study, pretest, and posttest, was conducted between 27 December 2023 and 22 March 2024 (a total of 88 days). Students studying at Kütahya Dumlupınar University Department of Interior Architecture in the fall semester of the 2023-2024 academic year participated in the study. The spatial context used in the study, in which color preferences (color preferences independent of space and color preferences in the context of space) were determined, was determined as the design studio BMA-2, which was most frequently used by the participants.

In the pretest phase of the study, which was conducted with the participation of 198 randomly selected students, the color preferences of all students were taken theoretically (questionnaire method) and analyzed within themselves. The posttest phase was organized to measure the effect of the experimental procedure (24 different colors experienced on the front wall surface of BMA-2 with VR glasses) given to approximately half of the students (n=100) on color preferences. Results were the following:

- ✓ Among all participants, the order of hue preference independent of the spatial context (general color preference order) was blue, green, purple, red, orange, and yellow. After the experiment, red was slightly more preferred than purple. However, the difference is not statistically significant. Therefore, experiencing colors in the context of space with VR glasses does not significantly affect the general color preference order independent of the context. All shades of blue were the most preferred colors among the 24 colors given. The fact that blue is the most popular color in general is consistent with many studies in literature (Eysenck, 1941; Guilford, 1934; George & Margaret, 1938; Jastrow, 1897; Katz & Breed, 1922; Madden et al., 2000; Washburn, 1911; Von Allesch, 1925). Dark and pale shades of yellow and orange were the least preferred colors. The fact that yellow and orange are less popular than other colors is generally consistent with other studies in the literature (Eysenck, 1941; Guilford, 1934; Jastrow, 1897; Katz & Breed, 1922;). However, in a study conducted by George and Margaret (1938) with 500 university students, purple was preferred after yellow and orange (George & Margaret, 1938).

- ✓ The general order of color preference is approximately similar within the categories of basic colors, pale colors, light colors and dark colors selected from the Munsell color system, which have different characteristics in terms of value and chroma. Therefore, it can be said that the hue feature is more important than the brightness and value scale of the color in color preference. The result obtained is compatible with Kıran's (2012) study. In Kıran's (2012) study, it was found that the significant effect among the preferred colors was due to the color tone and the colors with short wavelength were preferred more (Kıran, 2012).

- ✓ The experimental procedure caused positive preferences only for the pale orange color out of 24 colors, except that experiencing colors indoors with VR glasses does not affect users' general preferences for colors. However, color preferences in the context of space were affected by the experimental process.

- ✓ Before the experiment, the top 5 most preferred colors for the BMA-2 design studio wooden wall surface among all participants were blue, white, beige, no preference, gray and green, respectively. As a result of the experimental procedure affecting contextual color preferences, the top 5 most preferred colors for the BMA-2 design studio were blue, orange, red, white and green, respectively. The white and beige colors preferred before the experiment were replaced by warmer and chromatic colors such as red and orange after the experimental procedure. The order of color preference of the experimental group after the experimental procedure was blue, red, orange, green, (yellow, purple)[3] and white.

- ✓ For the BMA-2 design studio, the basic and light blue colors were equally less popular among the blue shades, and the most preferred color was pale blue with Munsel color notation 5B 6/8, which has a medium value and medium chroma. The experimental treatment increased the preference for pale blue (5B 6/8) in the context of space. Some of the reasons for the preference of the participants who preferred blue color and its shades on the wooden wall surface of the design studio are as follows.

    - It is a color that gives comfort to the eye.
    - It gives a feeling of glamor and vitality.
    - A color that is not overwhelming and does not distort the focus.
    - It evokes peace as it evokes the sea and the sky.
    - It is soothing and makes you want to work.
    - Inspiration
    - It goes well with the blue furniture in the studio.
    - More compatible with the teacher's desk and other furniture
    - More suitable for the atmosphere of the space
    - Makes the studio environment feel more peaceful and creative

- ✓ Among the experimental group, yellow and purple were preferred by an equal number of people, but they were preferred last among the colors presented. Yellow color was interpreted positively in all 9 adjective-pairs indicating positive or negative states, while purple color was perceived positively only in terms of being modern and active. The blue color preference preferred by all participants for the BMA-2 design studio is consistent with the study of Baytn et al. (2005). In the study conducted by Baytın et al. (2005), the green-blue color coded 3050B50G was the second most preferred color for the wooden wall surface of the design studios. However, the purple color tone (light purple), which was preferred in the first place in the same study, was preferred in the last place by the experimental group (Baytın et al., 2005).

- ✓ Although white color was considered more suitable for the BMA-2 design studio than red and orange colors before the experiment, it was preferred by only 1 person in the experimental group after the experiment. Similarly, in a study conducted by Kwallek et al. (1996) with a total of 675 psychology students on the effects of colors used in the office environment on employee performance, white-colored offices were described as the least distracting offices and were preferred more. Nevertheless, it was determined that the errors made in white offices were higher than in other offices. The high preference for white color for the BMA-2 design studio before the experiment may be due to the fact that the students adopted white as the existing color of the space and did not experience different colors in the context of the space.

- ✓ The experimental procedure encouraged participants to make choices for the BMA-2 design studio. The 22 users who avoided making a choice before the experiment made at least one-color choice after the experiment. In the pretest phase, the 17 color type preferences obtained for the BMA-2 design studio before the simplification process decreased to 14 after the experiment. The difference is due to the experimental group. While only 1 person in the experimental group preferred white color other than the colors presented to them in the experiment, the control group continued to prefer various colors such as black, brown, and beige. This shows that basic color tones are sufficient for the BMA-2 design studio.

- ✓ In the color preference stage, experiencing the colors in the virtual reality space using VR

[3] The number of preferences for the colors yellow and purple given in parentheses is equal.

glasses without physically applying the colors to the space did not have a great effect on the general color preference. However, spatial color preferences were affected by the experimental procedure. In addition, it was observed that the experimental process facilitated preference making by reducing preference ambivalence and revealed preference tendencies for different colors other than the existing space colors. In this case, it is clear that the use of color names or color samples of certain sizes in interior color preference will not give accurate results. Therefore, it is recommended to show the users the materials in which colors are used in context during the color preference stages.

The results are limited to a small sample selected from a large population and a specific spatial context. All of the participants are interior architecture students, whether they have color knowledge or not. Therefore, future studies are needed to generalize the results for all individuals and different types of spaces.

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