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Article

The influence of learning space colours on students within attention, emotional and behavioural

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ABSTRACT

Environmental colours can affect users in terms of performance, aesthetics, emotion, etc., and can play a role in their actions. Previous studies have shown that environmental colours are effective on user perception. This research aims to find out how wall colours can impact students in the learning environment by manipulating their attention, emotion, and behavioural reactions. An experiment was conducted with students aged 8–9 years in a real classroom painted in twelve colours. The students have taken the courses within a classroom having different wall colours (red, yellow, green, blue, purple, orange, green–yellow, blue–green, purple–blue, red–violet, white and grey) for twelve consecutive weeks during the experiment. In this process, various measurements and evaluations were conducted for each different colours regarding attention, emotion, and behaviours. The results show that learners' attention notably increased in the red–purple and yellow wall colours and decreased in the orange, purple, red, and blue wall colours. The students mostly preferred green–yellow, blue–green, orange, purple, and blue wall colours, and the least preferred ones were grey, yellow, and red–purple colours. The red, orange, green, green–yellow, blue–green, blue, and purple wall colours were perceived as positive by students. From behavioural point of view, they were more active in red, orange, yellow, and blue–green, whereas they were calmer in purple, red–purple blue, and green. In the grey wall colour environment, students were observed as bored and distracted, and there was a slight decrease in their attention in the course.

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INTRODUCTION

There are various studies about colour effects on users regarding attention, emotional and behavioural, in the literature. Studies on the effects of environmental colour have developed in parallel with the effects of space and environmental evaluations on users. Pressey found that there was no difference in the responses of warm and cold colours on the autonomic nervous system, whereas luminance increased performance speed (Pressley, 1921). Birren focused on the psychological and emotional areas of colour, especially on the tangible benefits of colour and lighting in interior spaces requiring performance (Birren, 1973).

In the literature, interior colour studies were carried out

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for different functions such as living room, office and classroom. The studies for the effects of the interior colours on the users can be exemplified as follows.

Ainsworth et al. assessed the work performance and the responses of the subjects (18–24-years-old) to anxiety, depression and arousal in red, blue–green and white-coloured experimental settings organised as office spaces. It was concluded that there was no difference between the rooms painted in different colours in terms of both performance and affective reactions (Ainsworth et al., 1993). Kwallek et al. investigated the effects of office wall colours on people's colour preferences, mood, and work performance (Kwallek et al., 1996). Although there was no significant relationship found between mood and office colours in the study, participants were more satisfied with working in rooms with low-value and high-saturation colours. Subjects made more mistakes in the white room than in the red and blue room, and in terms of work performance, subjects made high-scores in rooms with high-saturated wall colour room than in rooms with low saturated walls.

Küller et al. conducted three different experiments to assess the affective and neurophysiological effects of office colours on users aged 17–54 years. In the first experiment, a visually complex room with colours and patterns was created and in the second and third experiments, a red room and a blue room were compared. The results showed that saturated colours and complexity, red and similarly coloured rooms activated the brain whereas the blue room have a calming effect. In terms of colour effects on performance, the results of the experiment show that for the subjects who had inward and negatively oriented personalities, the red colour had an enhancing effect on performance. According to the results of all three experiments, it was concluded that individuals with a high-level of attention performed better in the red office, and adult individuals with lower attention capacity performed better in the blue room (Küller et al., 2009). In the study realised by Manav et al., the emotional effects of colour and lighting on adult individuals who created office spaces in a lab were investigated. The results of the study, in which both high-and low-saturation of blue and yellow wall colours were evaluated under different lighting scenarios, confirm that space colour perception is closely related to quantitative and qualitative properties of light. Besides, it has been found that even when the colour hue remains constant, environmental evaluations change as the saturation of the same hue changes (Manav et al., 2009).

In another study performed by Yıldırım et al., two separate living room images visualised on the computer were shown to the adult subjects on a projection screen. On the walls of the living rooms, which were furnished in two different ways, three different colours were applied: red, blue and grey (monochromatic). The participants aged 18–24 years found the warm (red) hue as "highly stimulating" and "exciting", and the cold (blue) hue as "spacious", "relaxing" and "peaceful". Grey space was generally defined with adjectives that resulted in the colour being negatively characterised (Yıldırım et al., 2011). Park's study examined the living room colour preferences of children aged between 7 and 11 years and the relationship between these preferences and colour components via the 1:12 scale room model. Forty-five colours were applied to the walls of the model, and were asked to the children, and which one they prefer most. Children preferred the red colour in medium value and saturation, the yellow colour in high-value and medium saturation, the green colour in medium value and saturation, and the blue colour, respectively. In terms of gender, it was found that girls preferred red and purple colours more in terms of hues whereas boys preferred less saturated colours within both red and purple hues (Park, 2013).

Al-Ayash et al.'s one of studies on the colour effect in learning environments assessed the moods and performances of the subjects aged between 20 and 38 years using high-saturation and high-value versions of blue, yellow and red colours and low saturation and high-value versions of the same hues in an experiment room. The results of the study showed that blue colours had a relaxing effect, whereas high-saturated hues significantly increased the performance scores (Al-Ayash et al., 2016). Tikkanen, on the other hand, studied the effects of changes in colour and lighting on emotions around the school environment with students aged 16 years. The students associated warm with pleasantness and cold with unpleasantness for both light and colour (Tikkanen, 1976). In a study conducted at an architectural studio of a university by Baytin et al., the wall with the blackboard was painted with thirty-four different colours each week. The effects of wall colours on the undergraduate students' tastes and moods as well as their performance were evaluated during this period. Purple and green–blue were the most preferred colour types, which the students stated as having soft, positive and relaxing effects. The colours which increased the students' attention in terms of academic efficiency were orange and purple, and the colours that decreased attention the most were yellow and yellow–green wall colours (Baytin et al., 2005).

The purpose of Wang and Russ's study was to investigate the relationship between computer lab wall colour preferences and undergraduate students' personality types. In the study, a classroom with computers was visualised and the wall with the blackboard was painted with 15 different colours. Purple, blue and blue–purple were the most preferred colours by undergraduate students (Wang and Russ, 2008). Yildirim et al. evaluated students' perceptual performance by showing university students the images of a digitally visualised classroom with walls painted with high-value yellow (cream), blue and pink colours. According to the results, it was found that blue-coloured classrooms were perceived more positively than yellow and pink-coloured classrooms (Yildirim et al., 2015).

Learning spaces in other words classrooms within which students spend a large part of their lives from early childhood to adolescence play an important role in their physiological, social, and cognitive development of them. Functionally expectations from these spaces are to provide suitable and efficient studying conditions for students. In a classroom, that has form and size are generally defined by standards and physical environment properties (materials, textures, patterns, lighting features, surface colours, etc.) can have an impact on students throughout their education. One of the physical components that affect students as environmental stimuli is wall colours that occupy a large part of the classroom surfaces. Students take courses under the effect of the colour stimuli reflected from the walls. These colour stimuli can influence students by manipulating their attention on the lesson, emotional or behavioural outputs.

In this context, this research was planned to find out how wall colours can impact students in the learning environment by manipulating their attention, emotion, and behavioural reactions. The research was conducted with students aged 8–9 years in a real classroom painted in twelve colours throughout the academic term and the students continued their courses under red, yellow, green, blue, purple, orange, green–yellow, blue–green, purple–blue, red–violet, white, and grey wall colours during the experiment. In this process, various measurements and evaluations were realised for each different colour within the scope of attention, emotional effects, and behaviours.

The majority of predecessor studies carried out on colour effects are mainly focused on adult users, and they have been conducted through visualisations and laboratory experiments. The most significant aspect that distinguishes our research from similar studies is that the experiment takes place in a real classroom environment throughout the academic term with children. The main purpose of this study is to determine the environmental colour conditions that should be supported learning in classrooms and to reach useful results in the colour design of the learning environment. On the way to this goal, the research has been planned in line with the fact that each different wall colour can create different effects, and the effects of these colours on students are evaluated in three attitudes such as attention, emotional, and behavioural response. Details of the in-site experimental research are given below as materials, methods, and results.

MATERIALS AND METHODS

The research was planned to determine the attention, affective and behavioural effects of the colours on the walls of a primary school classroom on students. The stages of the study are as follows;

- Determination of classroom wall colours,
- Arranging the classroom as an experimental space,
- Determination of methods of attention, affective and behavioural response to environmental wall colour,
- Evaluation of results.

PARTICIPANTS

Jean Piaget who has described learning according to the "theory of individual's mental development" and has accepted it as an age-related process, has described the period of 7–11 years as the period of concrete processing in which individuals can bring logical solutions to problems. So, the reason for concrete models and their reactions to environmental stimuli would be in this direction (Brainerd, 1978). The learning speed of individuals in the cognitive concrete operational thinking period is very high between 7 and 11-years-old. In parallel, the emotional and behavioural responses of students in this age group to the environment differ from adults. For this reason, students from the 8–9-year-old age group, who are within the period of concrete operational thinking were preferred for the study as subjects. A total of 35 students (22 females, and 13 males) participated in the study.

DETERMINATION OF WALL COLOURS

Twelve wall colours, using the Munsell Colour System were determined in the experiment. The chromatic colours are ten hues with equal perceiving steps (red, orange, yellow, green–yellow, green, blue–green, blue, purple–blue, purple, red–purple) and achromatic colours are white and grey. Every hue has the same value (7) and saturation (8) in order to create a similar perception for all colour hues. Table 1 demonstrates Munsell Colour System symbols for wall colours chosen for the study. Figure 1 shows equal steps of hues (Value: 7, Chroma: 8) of the Munsell Colour System (Munsell, 1971; Munsell, 2016; Luke, 1996). The ceilings

Table 1. Notations of Munsell colour system for wall colours

WALLS	Hue	Value/ Saturation	Color Sample
RED	5R	7/8	
ORANGE	5YR	7/8	
YELLOW	5Y	7/8	
GREEN-YELLOW	5GY	7/8	
GREEN	5G	7/8	
BLUE-GREEN	5BG	7/8	
BLUE	5B	7/8	
PURPLE-BLUE	5PB	7/8	
PURPLE	5P	7/8	
RED-PURPLE	5RP	7/8	
WHITE	N	9/o	
GREY	N	7/o	

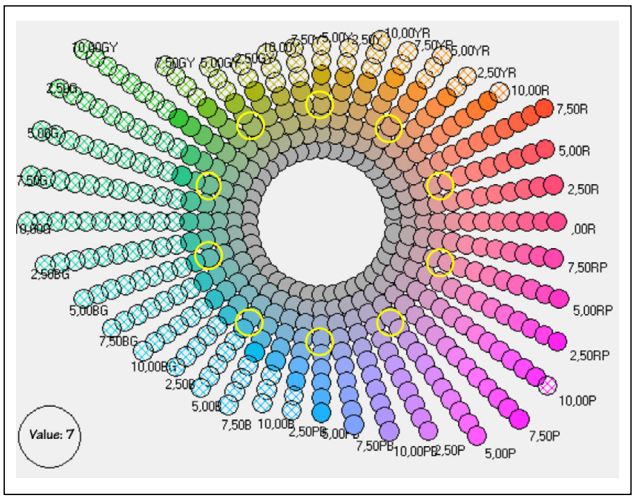

Figure 1. Ten chromatic colours determined from Munsell colour system in equal step (Value: 7, Chroma: 8) (Munsell, 2016).

of the experimental class were painted white (N 9/0). All furniture in the classroom was converted into grey in order to not decrease to wall colour effect. The students took their courses during the experiment.

MEASUREMENTS AND PROCEDURES

Colour Blindness: "Ishihara Colour Vision Test" was applied to all subjects to check their colour vision prior to the experiment. As a result of this control, it was determined that subjects had no colour vision defect (Ishihara, 1990).

Measurement of Attention Response: Within the scope of attention response, the "attention test" method was used to determine the extent to which classroom wall colour affects students' attention levels. The age and cognitive levels of the students were taken into consideration, it was picked a test they could comprehend easily and that would not take too long. Eventually, the letter form of the Bourdon Attention Test was found suitable for this study (Brickenkamp et al., 1975). The Bourdon Letter Test, which consists of 3 blocks and 660 letters was used as 2 blocks and 440 letters considering the age of the subjects. The 3-minute period given to the subjects in the three-block application was shortened to 2 minutes in this two-block application. Within 2 minutes, subjects were asked to find and mark the letters "a, b, d, g".

Measurement of Emotional Response: In order to evaluate the students' responses to classroom wall colours in terms of emotional effects, the "Environmental Colour Assessment (ECA)" form was prepared by using attitude scales which consist of two parts. In the first part of the form, on how the students perceive the classroom wall colour, the "Semantic Differential Scale (SDC)" consists of five levels and ten adjective pairs. In the second part, to determine the students' level of satisfaction with the classroom wall colours, "Likert Scale (LS)" with ten levels was prepared (Adams and Osgood, 1973; Küller, 1972; Küller, 1973; Osgood et al., 1957; Anderson, 1988; Groat and Wang, 2013; Joshi, 2015). The ECA test was applied to the students every week for each wall colour.

Measurement of Behavioural Response: The "Teacher Observation Form (TOF)" was prepared to determine the effects of classroom wall colours on students' behaviour. During the 12-week experiment period, the class teacher evaluated students' behaviour including class participation, concentration periods, students' mobility, talking, etc. in general throughout the week for each wall colour. In the first part of the Teacher Observation Form, which consists of two parts, the teacher evaluates her observations on students' behaviours according to a five-level scale and the second part includes her evaluation including written comments.

Experimental Settings

The study was carried out in a classroom with the dimensions of 7.15 m × 7.20 × 3.10 m as seen in Figure 2. On one wall of the classroom space, there are four windows directed to the Northwest. The current classroom layout was converted into the experiment space by making some arrangements.

Desks and panels on the walls were covered with medium grey fabrics, cabinets were covered with medium grey cardboards. Since the colour of the floor and curtain materials have high-value and low saturation, no new arrangements had been made. The white ceiling surface again was painted in white colour. The visual and written materials on the walls, which had the intensity to decrease the effect of the wall colour, had been reduced to the minimum number required for education.

Improvements have been made in the artificial lighting system to provide the values in the relevant standards. The lamp types changed while maintaining the positions of the luminaires. In this context, 36 W fluorescent lamps with

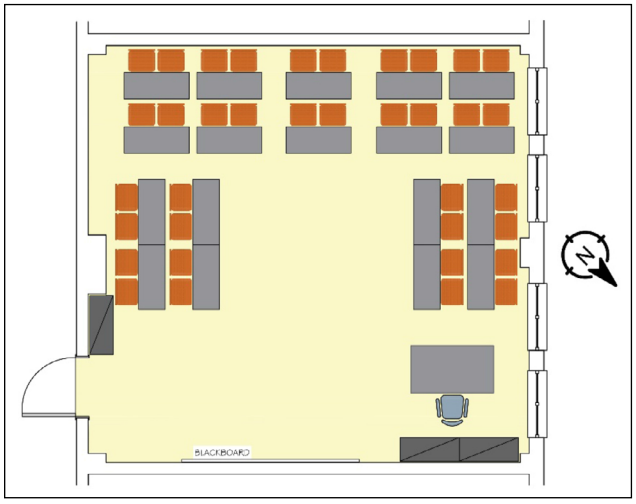

Figure 2. Classroom plan.

colour rendering index 1A (Ra> 80), colour temperature (Tc) 4000 K and light flux 3200 lm were used. By this way, the artificial illuminance realised on the desks had been minimum 300 lm/m^2 and it was made sure that all lamps were working properly.

There was no change in the natural lighting system, curtains were kept open, and both natural and artificial light was used together during the experiment. Since the windows were facing Northwest and the students were in class during the morning, the classroom was illuminated by sky light and artificial light.

The chosen wall surface colours were produced by a paint company in accordance with the specified Munsell Colour System and were applied after checking the accuracy of the colour properties. Class walls were painted during the weekend holidays. Education continued throughout the five weekdays with the wall colour applied for that week (Figures 3–6).

Figure 3. Red (5R 7/8), orange (5YR 7/8) and yellow (5Y 7/8) coloured wall class photos.

Figure 4. Green–yellow (5GY 7/8), green (5G 7/8) and blue–green (5BG 7/8) coloured wall class photos.

Figure 5. Blue (5B 7/8), purple–blue (5PB 7/8) and purple (5P 7/8) coloured wall class photos.

Figure 6. Red–purple (5RP 7/8), grey (N 7/0) and white (N 9/0) coloured wall class photos.

RESULTS

Attention Results

SPSS 10 (Statistical Program for Social Sciences) statistical program was used to analyse and evaluate attention results obtained by the Bourdon Attention Test (BAT) data. Furthermore, to control the reliability of the data, the "Test-retest reliability method" was used.

To find out whether there is a statistically significant difference between the first wall colour and the twelfth wall colour, two pre-tests and one post-test was applied. Thus, the experiments in the study continued for 15 weeks. The arithmetic mean results of the Bourdon Attention Test and the graphical representation are shown in Table 2 and Figure 7.

As the weeks progressed, attention test scores increased positively (Figure 8, Table 2). This positive rise in the scores revealed that "repeat-based learning" affects test scores, even though the order of letters in the attention test was changed every week. This is due to individuals' learning processes being based on repetition. No matter how influential the independent variables affecting attention are, the individual's test scores will increase by a certain amount each time when similar tests are applied. This situation is based on the repetition effect theory in the literature (Hebb, 1961; Szmalec et al., 2009; Johnson et al., 2017). Thus, it is important to obtain realistic results by subtracting the learning effect in order to assess correctly the effect of environmental stimuli on attention. Hereby, in this study, a method that eliminates the effect of repeat-based learning has been developed to accurately measure the effect of wall colour on attention. Accordingly, within the scope of the study, the procedure begins firstly with "determining the increase in students' scores learning due to repetition", in other words, determining the learning styles of the students. Then the assessment procedure is followed by subtracting these determined results from the Bourdon Attention Test values.

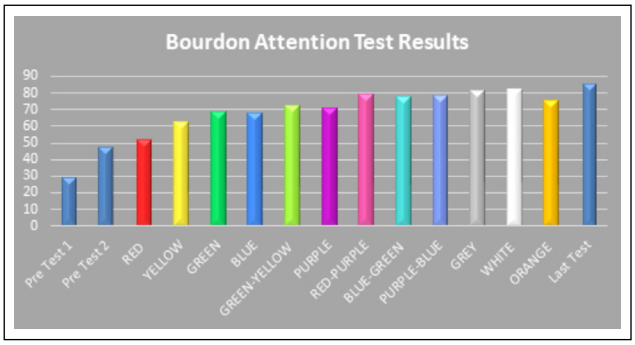

Figure 7. Bourdon attention test results graphic.

Each person or group has a way of learning and a function that demonstrates it (Carlson, 1973; Jaber and Guiffrida, 2004; Jaber, 2011; Pusic et al., 2015, 2016). In order to determine the increase in attention points in repeat-based learning, it is necessary to determine the function type of the students' learning styles. For this reason, the primary aim was to find out the "functional learning structure" of "Bourdon Attention Test scores obtained via repeat-based" for each student. An investigation was carried out to indicate which of the 10 functions "Linear, Logarithmic, Inverse, Quadratic, Cubic, Compound, Power, S, Growth,

Table 2. Arithmetic average of Bourdon attention test results

Week	Wall Colour Number	Wall Colours (Munsell colour system; Hue value/Chroma)	Bourdon Test Result (Average)
1st Week		Pre-test 1 (yellow–3Y 8/2)	29.26
2nd Week		Pre-test 2 (yellow–3Y 8/2)	47.91
3rd Week	1	Red (5R 7/8)	51.85
4th Week	2	Yellow (Y 7/8)	62.27
5th Week	3	Green (5G 7/8)	68.86
6th Week	4	Blue (5B 7/8)	68.13
7th Week	5	Green–Yellow (5GY 7/8)	72.65
8th Week	6	Purple (5P 7/8)	70.70
9th Week	7	Red–Purple (5RP 7/8)	79.30
10th Week	8	Blue–Green (5BG 7/8)	77.71
11th Week	9	Purple–Blue (5PB 7/8)	78.24
12th Week	10	Grey (5N 7/0)	81.31
13th Week	11	White (9N 0/0)	82.46
14th Week	12	Orange (5YR 7/8)	75.15
15th Week		Last test (Orange – 5YR 7/8)	85.40

and Exponential" were suitable for the functional structure of Bourdon Test scores. The best learning function was determined Cubic function as a result of the investigation by using the "Curve Estimation" module in the SPSS program. In the other words, the students' repeat-based Bourdon test scores are mostly in accordance with the "Cubic Function". The "deviations" within this function were assumed as "the effect of classroom wall colours on attention" and the evaluation was performed accordingly.

Bourdon Attention Test scores (raw scores) of students as shown in Table 2 were modelled according to "Cubic function" by regression analysis and colour effect data representing the differentiation of real values from theoretical values were prepared. Equivalence of the average effect of each colour on students to "0" was tested using the "One Sample T-Test". Since the number of samples was over 30, a non-parametric test was not used. Assuming that "each deviation" in the resulting cubic functions was "the wall colour effect on attention", it has been evaluated with the logic of "the wall colour with a greater standard deviation, had affected the attention more".

The Elimination of the Learning Effect (ELE Method)

With the elimination of the learning effect (ELE) method, the rise in attention scores due to repeat-based learning was eliminated from the test results via the cubic function. ELE was calculated by subtracting the theoretical values expected from the learning function from the estimated values. In other words, the mean of deviations in the learning function was tested to see if they were significant.

The "p" values of the significance level obtained from the "One Sample T-test" results were evaluated when the values were $p<0.01$ (99% significant), $p<0.05$ (95% significant), and $p<0.1$ (90% significant). It was determined that the average effect score obtained from the wall colours having "p" values satisfying these conditions had a positive (increasing points) or negative (decreasing points) effect according to the value. Table 3 shows the results of "one sample T-test with eliminated repeat-based learning effect (no learning effect)" for all students.

The numerical values showing the relationship between the twelve wall colours applied to the classroom walls and their

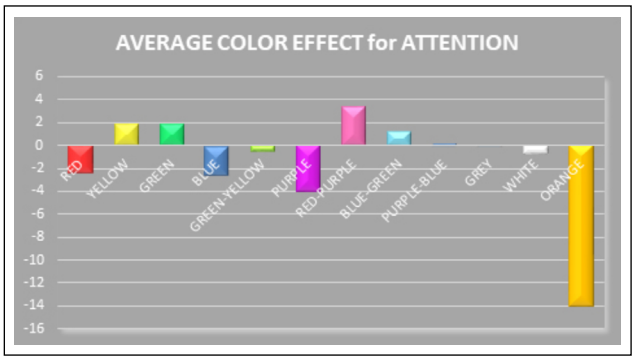

Figure 8. Average wall colours effect for attention (without learning effect).

Table 3. The results of "One Sample T-Test" with eliminated repeat-based learning effect

Colours	Test Value = 0						
	t	Df	Significant (2-tailed)	Average Effect	95% Confidence Interval of the Difference		Effect Size
					Lower	Upper	
Pre-test 1	-2.662	33	0.012**	-2.08630	-3.6810	-0.4916	2.55
Pre-test 2	3.930	33	0.000***	+3.67195	1.7710	5.5730	3.93
Red	-1.985	33	0.056*	-2.35473	-4.7685	0.0590	1.98
Yellow	1.871	33	0.070*	+1.88568	-0.1653	3.9367	1.87
Green	1.444	33	0.158	+1.84021	-0.7521	4.4325	1.44
Blue	-2.366	33	0.024**	-2.58352	-4.8048	-0.3623	2.37
Green–Yellow	-0.362	33	0.720	-0.49289	-3.2650	2.2792	0.36
Purple	-3.678	33	0.001***	-4.03176	-6.2619	-1.8016	3.68
Red–Purple	2.942	33	0.006***	+3.39955	1.0482	5.7509	2.94
Green–Blue	1.029	33	0.311	+1.23101	-1.2040	3.6661	1.03
Blue–Purple	0.189	33	0.852	+0.16465	-1.6112	1.9405	0.19
Grey	0.076	33	0.940	+0.07867	-2.0307	2.1881	0.08
White	-1.121	33	0.271	-0.72255	-2.0342	0.5892	1.12
Orange	-6.429	32	0.000***	-14.00910	-18.4476	-9.5706	6.43
Last test	-3.359	29	0.002***	-13.32443	-21.4384	-5.2105	3.36

It displays significance at *90%, **%95, ***99% confidence level.

Table 4. Ranking of Bourdon Attention test arithmetic average results (Raw Scores-with learning effect)

Week	Bourdon Test Colour Ranking According To Raw Scores		Bourdon Test Results (Raw score)
11st Week	1st	White (11)	82.46
10th Week	2nd	Grey (10)	81.31
7th Week	3th	Red–purple (7)	79.30
9th Week	4th	Purple–blue (9)	78.24
8th Week	5th	Blue–green (8)	77.71
12th Week	6th	Orange (12)	75.15
5th Week	7th	Green–yellow (5)	72.65
6th Week	8th	Purple (6)	70.70
3rd Week	9th	Green (3)	68.86
4th Week	10th	Blue (4)	68.13
2nd Week	1th	Yellow (2)	62.27
1st Week	12th	R`ed (1)	51.85

Table 5. Ranking of Bourdon Attention test results after ELE method (Reliable Scores-without learning effect)

Week	Colour ranking independent from time effect		Average effect scores (Clear Scores)
7th Week	1st	Red–purple	3.399***
2nd Week	2nd	Yellow	1.885*
3rd Week	3th	Green	1.840
8th Week	4th	Blue–green	1.231
9th Week	5th	Purple–blue	0.164
10th Week	6th	Grey	0.078
5th Week	7th	Green–yellow	-0.492
11st Week	8th	White	-0.722
1st Week	9th	Red	-2.354*
4th Week	10th	Blue	-2.583**
6th Week	1th	Purple	-4.031***
12th Week	12th	Orange	-14.009***

It displays significance at *%90 (p<0.1), **%95 (p<0.05), ***%99 (p<0.01) confidence level.

effects on attention are presented in Table 3. According to these values, six colours (red, yellow, blue, purple, red–purple and orange) among the applied colours showed a significant effect (p<0.1). Among these six colours, yellow and red–purple had a significantly increasing average attention effect, while red, blue, purple, and orange wall colours had a decreasing average attention effect. The other six colours (green, green–yellow, blue–green, purple–blue, grey, and white) were ineffective, i.e. had greater values as "p>0.1". In this case, it can be stated that "six colours did not have a statistically significant effect".

As seen in Tables 4 and 5, the values in the Bourdon Attention Test obtained by application of the ELE method give only the results of the effects of wall colours on attention regardless of the repeat-based learning effect. After the application of ELE method, the highest score was reached with "red–purple" wall colour (p<0.01). In other words, the red–purple colour has had the significant most positive effect on students' attention. This colour is followed by "yellow" colour with an increase of 1.885 points (statistically p<0.1). On the other hand, the "green" wall colour, which shows a very close score similar to the yellow colour with an increase of 1.84 points, does not give a statistically significant (p>0.1) result. After application of the ELE method, red, blue, purple, and orange colours have had negative values in terms of average effect without learning effect (reliable scores). These wall colours can be identified as colours that negatively affect student attention (Figure 8).

EMOTIONAL RESULTS

The students' responses to classroom wall colours in terms of emotional effects were determined by the "Environmental Colour Assessment (ECA)" form. It has "Semantic Differential Scale (SDS)" for adjectives and "Likert Scale (LS)" for preference of wall colours. Findings of the emotional response are given in Tables 6 and 7, as an arithmetic mean and standard deviation values in terms of SDS and LS.

Semantic Differential Scale findings: The data on the Semantic Differential Scale (SDS) were evaluated by the arithmetic mean method on all subjects ignoring the gender difference. The result of semantic profiles of twelve colours was divided into three graphics for clearer perception. The first graphic involves the main five colours (red, yellow, blue, green, and purple), the latter graphic involves five mid-colours (Orange, Green–Yellow, Blue–Green, Purple–Blue, Red–Purple) and the third graphic involves two achromatic colours (white and grey).

According to the arithmetic means of the Semantic Differential Scale (SDS), users' semantic responses to variables for each wall colour are shown in Figure 9a (red, yellow, green, blue, purple), Figure 9b (orange, green–yellow, blue–green, blue–purple, red–purple) and Figure 9c (grey, white). In this scale, where each variable is evaluated with two opposing adjectives and five intervals, the adjective pairs are graded from -2 to +2. The areas below the "0" axis define the negative references given by the users about the wall colour for each adjective and the areas above the "0" axis define the positive references.

The red, orange, green, green–yellow, blue–green, blue, and purple wall colours were perceived as "positive" for all

Table 6. Mean (M) and standard deviation (SD) values of semantic differential scale (SDS)

COLOURS		Adjectives / SDS									
		Ugly/ Beautiful	Boring/ Interesting	Unpleasant/ Pleasant	Dark/ Light	Lifeless/ Alive	Passive/ Active	Sour/ Sweet	Cold/ Hot	Heavy/ Light	Dirty/ Clean
Red	M	1.29	0.71	1.29	1.15	1.38	1.35	0.91	1.06	0.76	0.71
	SD	1.09	1.38	0.94	1.18	1.02	1.04	1.36	1.28	1.33	1.57
Yellow	M	0.59	0	0.71	0.88	0.56	0.56	0.41	-0.18	-0.44	-0.21
	SD	1.35	1.44	1.4	1.41	1.58	1.48	1.44	1.53	1.48	1.57
Green	M	1.18	0.56	1.06	0.68	0.85	0.97	1.18	0.65	0.35	1.06
	SD	1.27	1.42	1.28	1.34	1.48	1.14	1.14	1.39	1.5	1.35
Blue	M	1.38	0.91	1.12	1.38	1.35	1.03	1.24	0.85	0.59	1.06
	SD	0.99	1.31	1.2	1.1	1.1	1.19	1.16	1.26	1.54	1.28
Purple	M	1.09	0.82	0.97	1.09	0.91	0.76	1.24	0.74	0.74	0.52
	SD	1.44	1.47	1.49	1.31	1.4	1.37	1.28	1.48	1.48	1.58
Orange	M	1.22	0.91	1.01	0.88	1.15	0.69	1.01	0.58	0.54	1.27
	SD	1.13	1.16	1.26	1.3	1.26	1.41	1.3	1.48	1.42	1.15
Green–yellow	M	1.29	1.06	0.93	1.1	1.17	0.8	1.09	0.51	0.75	0.97
	SD	1.04	1.08	1.18	1.19	1.24	1.33	1.2	1.36	1.28	1.34
Blue–green	M	1.22	0.86	1.14	0.91	1.01	0.81	1.06	0.59	0.78	0.87
	SD	1.06	1.3	1.1	1.26	1.38	1.37	1.15	1.45	1.43	1.84
Purple–blue	M	0.78	0.22	0.51	0.09	0.22	0.21	0.35	-0.04	0.31	0.31
	SD	1.3	1.49	1.32	1.54	1.63	1.41	1.53	1.34	1.51	1.54
Red–purple	M	0.42	0.18	0.29	0.11	0.21	0.03	0.58	0.12	0.39	0.33
	SD	1.41	1.52	1.61	1.62	1.67	1.51	1.5	1.49	1.63	1.54
Grey	M	-0.15	-0.39	-0.45	-0.52	-0.7	-0.61	-0.64	-0.64	-0.61	-0.97
	SD	1.7	1.77	1.7	1.7	1.61	1.66	1.67	1.6	1.52	1.43
White	M	0.18	-0.18	0.13	0.22	0.21	0.09	-0.01	-0.19	0.06	0
	SD	1.47	1.51	1.58	1.56	1.73	1.49	1.58	1.56	1.4	1.78
Total	M	0.87	0.49	0.71	0.63	0.69	0.52	0.7	0.32	0.4	0.54
	SD	1.34	1.46	1.42	1.47	1.54	1.46	1.45	1.49	1.5	1.61

Table 7. Arithmetic mean (M) and standard deviation (SD) values of Likert scale (LS)

		Red	Yellow	Green	Blue	Purple	Orange	Green–yellow	Blue–green	Purple–blue	Red–purple	Grey	White	Total
Satisfaction (LC)	Mean	7.82	6.47	8.12	7.91	7.91	7.7	7.86	9.43	6.06	6.3	4.72	5.43	7.16
	SD	2.94	3.52	2.65	2.52	3.07	2.76	2.65	12.38	2.98	3.02	3.77	3.29	5.17

adjectives. While purple–blue and red–purple wall colours were also perceived as "positive", they were not as much as the others. The yellow (5Y 7/8) wall colour was perceived as bright, vivid, and energetic but in contrast, it was also perceived as dirty by the students.

The students characterised the white (N 9/0) colour around the zero axis and did not give a clear definition for it. Students' approach to this wall colour was slight as light, alive and active, but can be overall described as "indecisive" or "neutral" (Figure 9c). As seen from the graph in Figure 9c, the students found the grey (N 7/0) wall colour negative for each adjective and evaluated it to be particularly lifeless and dirty.

Likert Scale Findings: According to the arithmetic average results of the Likert scale given in Table 8, the student's favourite colour was the green–yellow (5GY 7/8) wall colour (90.88 points). The blue–green (5BG 7/8) wall colour followed as the second (89.41 points) and the orange (5YR 7/8) wall colour (84.55 points) came next. Students' least favourite colour for the classroom wall was medium grey

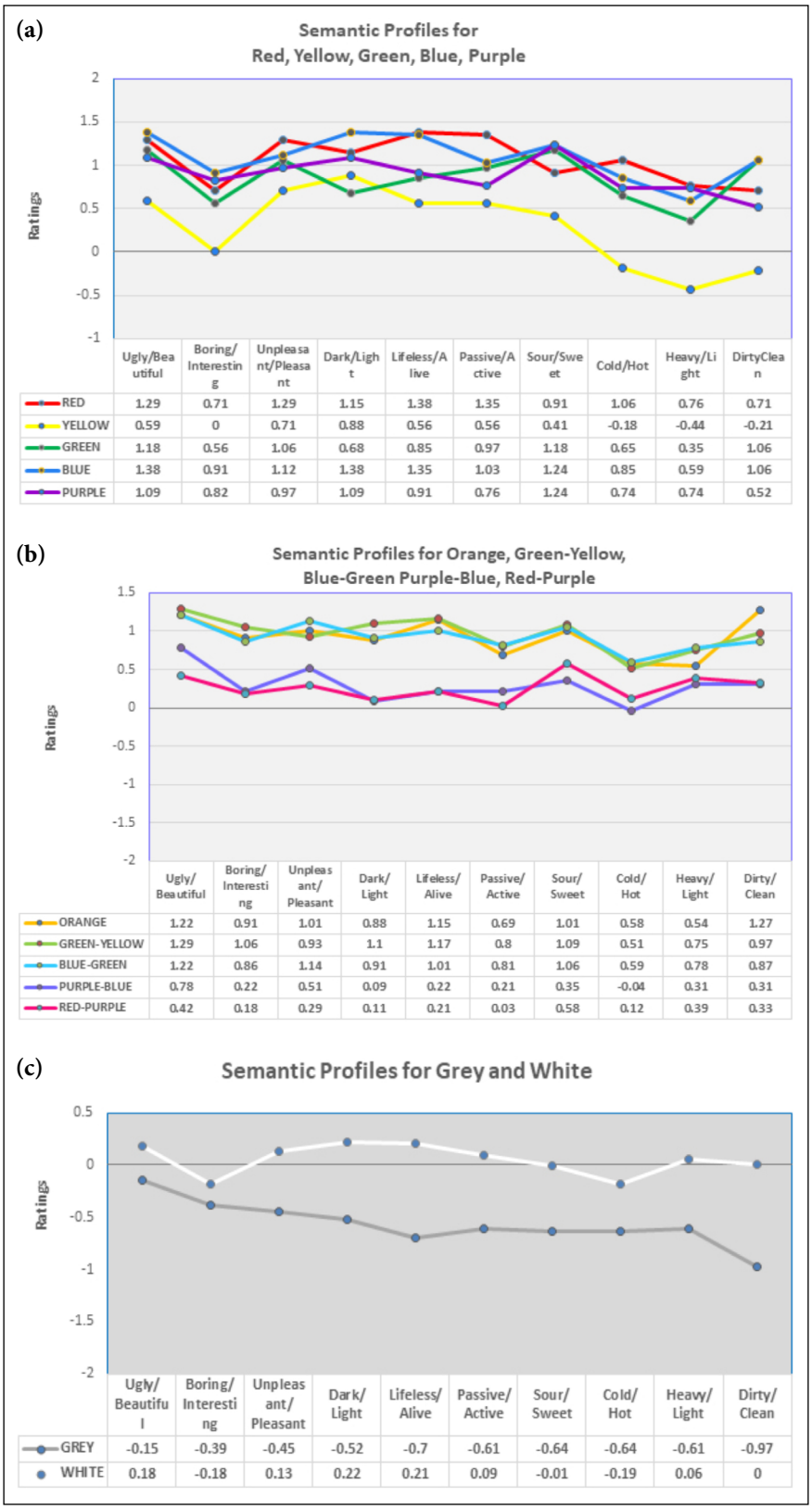

Figure 9. **(a)** Results of semantic differential scale (SDS) of red, yellow, green, blue, purple colours. (b) Results of semantic differential scale (SDS) of orange, green–yellow, blue–green purple–blue, red–purple colours. (c) Results of semantic differential scale (SDS) of achromatic (grey and white) colours.

Table 8. Likert scale satisfaction levels (%) of wall colours

	Wall Colour	Satisfaction Level (%)
1st	Green–yellow (5GY 7/8)	90.88
2nd	Blue–green (5BG 7/8)	89.41
3th	Orange (5YR 7/8)	84.55
4th	Green (5G 7/8)	81.18
5th	Purple (5P 7/8)	82.35
6th	Blue 5B 7/8)	80.88
7th	Red (5R 7/8)	76.47
8th	White (N 9/0)	67.00
9th	Purple–blue (5PB 7/8)	65.00
10th	Red–purple (5RP 7/8)	66.18
11th	Yellow (5Y 7/8)	64.41
12th	Grey (N 7/0)	47.27

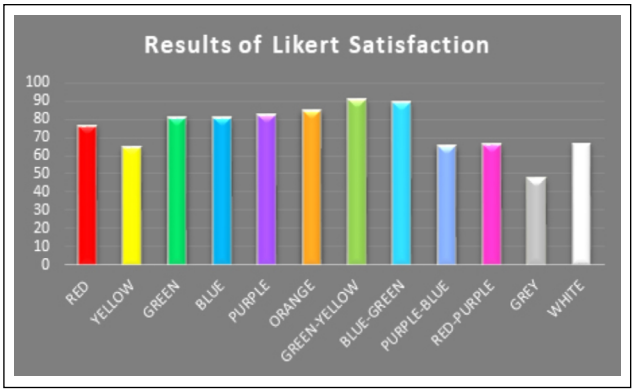

Figure 10. Likert scale satisfaction level (%) result as graphic.

(N 7/0) colour with 47.27 points. The scores were graded out of 100. A graphical representation of the Likert scale findings according to colour is presented in Figure 10.

BEHAVIOURAL RESULTS

Behavioural responses were evaluated according to the class teacher observation forms. This investigation is a qualitative assessment and was carried out to support the research. The evaluation of the information in the Teacher Observation Form can be summarised as follows:

Red (5R 7/8) Wall Colour: In the red wall environment, substantial fidgetiness was observed among the students. The students had been stimulated, their movements were more intense and disturbing than ever. They had trouble focusing on lectures and practices and talked among themselves without raising their hands. As a result, the teacher had difficulty in establishing discipline and the students were adversely affected by this classroom wall colour.

Yellow (5Y7/8) Wall Colour: The review of the teacher for the yellow wall colour was that this colour energised and cheered the students but also caused an increase in their attention to the lessons.

Green (5G 7/8 Wall Colour: For this wall colour, the teacher stated that the students were calmer when compared to their behaviours for the red and yellow wall colours, and their transition from an energetic activity to a more focused one was fast and they were surprisingly quick in adapting to the lesson. The teacher also underlined the observation of the students' noticeable calmness in this colour environment.

Blue (5B 7/8 Wall Colour): In the blue environment, the students were more compliant with the classroom and school rules. They took the warnings into consideration more quickly and they did their work efficiently.

Purple (5P 7/8) Wall Colour: The teacher stated that the students were stagnant, especially when they needed to study alone, but they generally talked a lot. In the blue environment, the course contents of the students were moderate.

Orange (5YR 7/8) Wall Colour: The orange wall colour made the students' energies surge in a positive way, they were cheerful and loving, and they participated in the lesson more.

Green–yellow (5GY 7/8) Wall Colour: In the green–yellow wall colour environment, the focus of students on the lesson increased, their complaints were reduced, they looked peaceful and the noise they made even while studying on their own was reduced, but the female students specifically were a little restless.

Blue–Green (5BG 7/8) Wall Colour: For the blue–green wall colour, the teacher stated that there was chaos in the classroom and it turned into a noisy environment in a very short time. In addition, the complaints and fights within the classroom had increased and she defined these observations as puzzling.

Purple–Blue (5PB 7/8) Wall Colour: The teacher stated that the overall processes and the courses were run as normal in the classroom. The usual changes were observed, there was no significant behavioural difference and there was no shift to the extremes in either a positive or a negative sense when compared with other wall colours.

Red–Purple (5RP 7/8) Wall Colour: In the week in which the red–purple wall colour was painted, a lot of activities had taken place in parallel with the children's day celebrations. The teacher reported that the students could concentrate on the subjects and activities very much and did not make any noise while studying on their own. After the completion of the experimental research, the teacher emphasised that she was most satisfied with the red–purple wall colour in terms of students' behaviour and attention.

Grey (5N 7/0) Wall Colour: The teacher noticed that, with the grey colour, the students were looking a bit numb and bored, their perception had slowed down, they did not

Table 9. General evaluation of responses towards wall colours

	Attention	Emotional		Behavioural
	Bourdon Attention Test	**Semantic Differential Scale**	**Likert Scale**	**Teacher Observation**
RED	Students' attention level scores (p<0.1, significant) decreased by an average of 2.3547	Red wall colour was found pleasant, lively, bright, active and warm, and "effective"	Ranked 7th out of 12 by 74.47 scores	The students stimulated and were fidgety, their movements have become more uncontrolled and intense than ever, and have had difficulty in focusing, the teacher has had difficulty in discipline
		Attention ↘ Emotional ↗ Behavioural ↘↘		
YELLOW	Students' attention level scores (p<0.1, significant) increased by an average of 1.8856	Students described the colour yellow light, lively and alive, but also somewhat dirty	Ranked 11st out of 12 by 64.41 scores	The students have elicited active and cheerful behaviour and their attention to the lessons increased
		Attention ↗ Emotional ↘ Behavioural ↗		
GREEN	Students' attention level scores (p>0.1, p=0.158) increased by an average of 1.8402	Green colour is described as "positive" for all adjectives	Ranked 5th out of 12 by 81.18 scores	Students were calm and focused swiftly to the lesson
		Attention – Emotional ↗ Behavioural ↗		
BLUE	Students' attention level scores (p<0.05, significant) declined by an average of 2.5835	Blue colour is described as "positive" for all adjectives	Ranked 6th out of 12 by 80.88 scores	They were calm, disciplined and have done their work efficiently
		Attention ↘ Emotional ↗ Behavioural ↗		
PURPLE	Students' attention level scores (p<0.01, significant) declined by an average of 4.03176	Purple colour is described as "positive" for all adjectives	Ranked 4th out of 12 by 82.35 scores	Students were stagnant, but generally talked a lot. The course contents of the students were moderate
		Attention ↘ Emotional ↗ Behavioural ↘		
ORANGE	Students' attention level scores (p<0.01, significant) declined by an average of 14.0091	Orange colour is defined as clear, beautiful and positive for other adjectives	Ranked 3th out of 12 by 84.55 scores	Students' energies have surged in a positive way, they were cheerful and loving, and they participated in the lesson more
		Attention ↘ Emotional ↗ Behavioural ↗		
GREEN–YELLOW	Students' attention level scores (p>0.1) decreased by an average of 0.4928	Green-yellow colour is called as "positive" for all adjectives	Ranked 1st out of 12 by 90.88 scores	The focus of students on the lesson increased, their complaints were reduced, they looked peaceful and calmer, but also the female students specifically were a little restless
		Attention ↗ Emotional ↗ Behavioural ↘		
BLUE–GREEN	Students' attention level scores (p>0.1) surged by an average of 1.2310	Blue-green colour is described as "positive" for all adjectives	Ranked 2nd out of 12 by 89.41 scores	There was chaos in the classroom, the complaints and fights within the classroom have had increased as puzzling
		Attention ↗ -- Emotional ↘ Behavioural ↗		
PURPLE–BLUE	Students' attention level scores (p>0.1, p=0.852) surged by an average of 0.1646	The colour is found to be "less positive" at close values for each adjective	Ranked 10th out of 12 by 65 scores	The overall processes and the courses were run as normal in the classroom. There was a balanced situation in the classroom
		Attention ↘ -- Emotional ↘ Behavioural -- ↗		
RED–PURPLE	Students' attention level scores (p<0.01, significant) increased by an average of 3.3995	The colour is found to be "less positive" at close values for each adjective	Ranked 9th out of 12 by 66.18 scores	The students could concentrate on the subjects and activities very much and did not make any noise while studying on their own
		Attention ↗ Emotional ↘ Behavioural ↗		
GREY	Students' attention scores (p>0.1, p=0.94) increased on average 0.0786, meaningless and insignificant	Grey colour is described as "negative" for all adjectives	Ranked 12th out of 12 by 66.18 scores	The students were looking a bit numb and bored, their perception have had slowed down, not make a lot of noise, and their communication capabilities have decreased
		Attention ↘ -- Emotional ↘ Behavioural ↘		
WHITE	Students' attention scores (p>0.1, p=0.271) decreased on average 0.7225	White colour is described as neither negative nor positive for all adjectives	Ranked 8th out of 12 by 67 scores	The students have not behaved consistently, they could focus studying on their own, but also even a small event that developed could suddenly has pushed the students into uncontrolled behaviours
		Attention ↘ -- Emotional ↘ Behavioural ↘		

make a lot of noise, and their communication capabilities decreased.

White (5N 9/0) Wall Colour: The teacher stated that the most remarkable point about the students was that they did not

behave consistently, they were focused even while studying on their own, and even a small event that developed could suddenly eliminate all the calmness and control, and pushed the students into uncontrolled behaviours. The teacher also stated that during the first few days with the white wall colour, while the students were concerned about the cleanness of the wall, they were not stable about keeping the wall clean, yet the wall remained less dirty than normal.

COMPARATIVE EVALUATION OF RESPONSES TOWARDS WALL COLOURS

The results of the study show that the effects of each wall colour on students occur differently in terms of attention, emotional and behavioural. In this sense, the responses of three different attitudes given by students to twelve different colours were evaluated collectively and comparatively summarised in Table 9.

DISCUSSION

In this study, in a primary school classroom painted in twelve different colours, one each week, students completed attention tests and environmental colour assessments throughout twelve weeks. In this process, the classroom teacher made evaluations by observing the behaviours of the students. Many significant results were obtained from the study in terms of attention, emotional and behavioural response. These outcomes have exposed similar but sometimes contradictory results to the other literature studies.

According to the environmental colour studies in the literature is that cold colours having shorter wavelengths such as blue and purple have a calming effect on people, while warm colours having longer wavelengths such as red, orange, and yellow have a stimulating effect on people (Thönes, 2018). The behavioural results of this study also show that the red wall colour stimulated the students and negatively affected their classroom behaviours. Similarly, the calming effect of the blue colour in the literature was also observed in this colour environment during the experimental process.

Al Ayashi et al. found that the performance of subjects increased in the red, blue and yellow environments (Al Ayashi et al., 2016). However, for our study, the participants' attention decreased in red and blue colour but increased with yellow colour. In contrast to the study of Küller, in our study, performance in the red environment decreased (Küller, 2009). Contrary to our research, in the study by Baytin et al. in the week when the yellow and green–yellow wall colour was applied, a decrease in the level of attention of the subjects/students was observed (Baytin et al., 2005).

The results of our research showed that the blue wall colour was satisfied by the students but this colour environment significantly reduced their attention. On the other hand, Kwallek et al. found that the blue colour decreased the attention, but in the study by Küller et al. on offices and in Al-Ayashi et al.'s experimental studies, it was observed that the subjects became calmer but their performance had increased in the blue wall-coloured environment (Kwallek et al., 1996; Küller et al., 2009; Al-Ayashi et al., 2016).

In contrast to the results of this study, subjects preferred orange wall colour as the least favourite colour in the studies of Kwallek and Wang. However, the preference for the orange wall colour as one of the most admired colours for the design studio by students in Baytin is parallel with this study (Kwallek et al., 1996; Wang, 2008). As in Yıldırım's study, grey was the least admired, boring and cold wall colour in this study, as well. Purple wall colour, which is one of the favourite colours, was the most admired wall colour for the class in Baytin's study (Baytin et al., 2005; Yildirim et al., 2007).

According to the study realised by Kwallek, the result that purple environment colour reduces attention is parallel with our study. In the study by Baytin et al., it was concluded that the students preferred the purple wall colour the most, and also there was an increase in the attention level of the students during the week when the purple, and orange wall colour was applied. In terms of attention, this study does not give the same result as Baytin's study (Kwallek et al., 1996; Baytin et al., 2005).

Evaluation of the behavioural attitude towards classroom colours was limited only to the observation of the classroom teacher. This evaluation was qualitative and it could not possible to analyse the result statistically. In addition, behavioural responses may change depending on the mood of the subjects during the observation period. In this context, the reason for including this evaluation in the study was to gather more detailed information and to support the overall study. The results of the qualitative assessment in this study may also help to form the hypotheses of other studies.

While determining the effects of wall colour on students' attention, the results of the study could be tested with a control group. In this case, the learning function of the control group should also be determined and its suitability with the learning function of the experiment group should be compared. It was not possible to test the results with an experimental group in this study.

CONCLUSIONS

The results of our study showed that come forward red-purple is the most positive colour within the scope of attention and behavioural response, and this wall colour has produced the highest increase in attention scores in

the relevant age group. In this wall colour environment, it was seen that there was a positive and parallel relationship between the attention and behaviours of the students. After the experiment was completed, the class teacher emphasised that she was most satisfied with the red–purple wall colour in terms of classroom behaviour and attention. Despite all these positive results in terms of cognitive (attention) and behavioural aspects, students were not satisfied with this colour in terms of the affective aspect.

The most negative colour in terms of impact on attention is the "orange (5YR 7/8)" wall colour, which has the lowest result in attention test scores. On the other hand, this wall colour was highly appreciated by the students and their behavioural attitudes also increased positively. The results of the study indicate that the most negative wall colour effective in both affective and behavioural contexts is grey (N 7/0). For the grey wall colour, the affective effects shifted slightly to a more negative area, as the students did not like the wall colour, they also became numb and silent, and their communication skills declined. This wall colour's results show that it was the least preferred colour in terms of affective aspects, it received negative responses for all the adjectives in the semantic assessment, and in terms of behavioural aspects, the students were tired, distressed, and had difficulty focusing.

The repetition of the Bourdon Attention Test, which was administered many times including the pre- and post-test, has led to positive increasing test score results. Since the main purpose of measuring the attention effect in the experiment was to assess the effect of the wall colour only, the "increasing scores due to repeat-based learning" were subtracted from these scores and obtained more reliable scores. For this purpose, the ELE (Elimination of the Learning Effect) method which was specifically developed for this study was used by utilising the existing statistical methods. This approach may guide other studies to obtain more accurate results in eliminating the repeat-based learning effect while measuring the effects of multiple dependent variables on attention, especially if there is no control group.

Within the scope of the effects of space colours on individuals, a study-specific method was applied in this field experiment research on the effect of classroom wall colour on 8–9-year-old students. In the context of the effects of classroom wall colour in educational spaces, this study was conducted to determine student attitudes that will support learning positively and it is aimed to contribute to the education sector. Apart from this research in which classroom wall colours and 8–9-year-old students were taken into consideration, planning of studies for different age groups, different socio-cultural levels and interiors with different functions will contribute to architectural colour science in terms of determining the indoor surface colours.

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