

INVESTIGATING THE EFFECTIVENESS OF DIFFERENT EDUCATIONAL METHODS IN IMPROVING THE ABILITY TO DETERMINE TOOTH COLOR BY DENTAL STUDENTS

Irina Seceleanu¹, Nicoleta Corcodel^{2*}, Kevi³, Alexander Hassel⁴, Christos Labis⁵

¹Department of Mathematics, Bridgewater State University, Bridgewater, Mass.

²University of Heidelberg Im Neuenheimer Feld 400 Heidelberg 69120 Germany. n_corcodel@icloud.com

³Department of Mathematics, Bridgewater State University, Bridgewater, Mass Rion.

⁴Department of Prosthodontics, University of Heidelberg, Heidelberg, Germany.

⁵Department of Prosthodontics, University Hospital Heidelberg, University of Heidelberg, Heidelberg, Germany.

<https://doi.org/10.51847/ExW8wL7xPp>

ABSTRACT

Matching tooth color with restoration is one of the most difficult tasks in restorative dentistry. One of the important aspects of dental education is teaching and learning color matching. The purpose of this study was to investigate the effect of the teaching method on improving the ability to determine color by dental students. In this study, dental students were randomly divided into two groups. The first group was taught the methods of tooth color matching in person and practically. In the second group, a training booklet was used for training. The students of each group were asked before, after, and after 1 month to determine the color of the samples using the Vita Classic color determination series. The evaluation of student's ability to determine color was done with the Pearson Chi-Square test with a sample size of 18 or 20 and with a confidence level of 95%. The training group with the booklet was significantly more successful in determining the color of the fourth sample ($P < 0.01$). In none of the studied groups and any of the color samples used, the results one month after the training were not better than the results before the training started. Also, there was no significant relationship between the accuracy of color determination with the gender of the students and the use of glasses. Therefore, the use of glasses and gender did not affect the accuracy of color determination. According to the obtained results, it can be concluded that training with a booklet is more effective than practical training for dental students in improving the accuracy of color determination.

Key words: Dental students, Tooth color, Educational methods, Color determination.

Introduction

Today, paying attention to the aesthetic dimension is one of the most important and most important aspects of treatment during the provision of dental treatments. As the level of society's culture rises and the growth and development of oral hygiene, people's attention to having beautiful-looking teeth is increasing day by day. When performing cosmetic treatments to create a beautiful and natural restoration, in addition to having the necessary knowledge, the dentist must consider other artistic factors such as the composition, shape, symmetry and proportion, color and transparency of the treated tooth, and coordination with the rest of the teeth and the patient's face. Consider to get the desired result [1, 2]. The science of color is one of the important tools to achieve this goal and obtain the best and most beautiful treatment result, for this reason, color is considered one of the important categories of dentistry [3-5].

It is possible that in a restorative or prosthetic treatment, all the necessary artistic factors have been observed, but due to an error in color selection, the treatment will fail. Incompatibility of the color of the restored tooth with other teeth can cause economic problems such as replacement, repair, or cost for the dentist, and result in patient dissatisfaction and adverse job consequences for the dentist

[6]. It is possible to measure and determine tooth color by visual methods or by using special devices. The eye method is done using Shade Guides and tools such as spectrophotometer and calorimeter can also be used to determine color [7-9].

Various research has shown that the feeling and perception of color varies from person to person. Gender may affect color selection and determination, but the results of studies on this matter are contradictory. The presence of different light and color sources can also cause different results [10, 11]. Color is a complex phenomenon, and its recognition is due to the existence of a physical stimulus and the exchange of psychophysical signals between the stimulus and the receptor cells of the eye, as well as the mental reaction of the brain to the information transmitted from the receptor organ. Therefore, it is important to report and understand all three parts of this set of stimulus, receptor, and interpretation in the brain, because a change in any of these parts causes a false or inappropriate understanding of the real situation [12, 13].

Due to the perceptual nature of color matching, the ability to choose color requires knowledge of the basic principles of color science, training, and clinical experience. For this reason, one of the important aspects of dental education is

teaching and learning color matching. However, the direct effect of training on the ability to visually evaluate color is not precisely known [14, 15]. This article has tried to compare and investigate the effect of two different teaching methods on improving the ability to determine tooth color by dental students, and in this regard, a more effective method should be used in the education of dental students.

Materials and Methods

In this prospective and interventional study, the sample size was calculated with values of $\alpha < 0.01$ and $\beta < 0.0$, and 40 people were considered in each group. In the implementation of this project, this number of students was divided into two groups based on the table of random numbers. The first group was students who were trained face-to-face to learn the methods of tooth color matching. In the second group, an educational booklet was used to teach the students. The variables included two different training methods, the gender of the participants, and the history of using prescription glasses. The face-to-face and practical training in the first group included participating in the professor's classroom on the subject of color selection and also seeing a demonstration at the patient's bedside for color selection. In the second group, these trainings were provided to the patients without being present in the classroom or at

the bedside, and only in written form in the form of pamphlets.

In this study, using the Vita Classic color determination series, the B4, D4, A2, and C2 color sample was selected and the corresponding color code was covered, and then, using another series of color samples, the students of each group were asked to choose from a complete Vita color sample. Determine the color of the samples before and after the training and also 1 month after the training and enter the desired color in the designed questionnaires. In determining the color of each sample, the answers were checked at two levels. The first is to correctly guess the desired hue (A, B, C, D) and the second is to correctly guess the Chroma number of each color sample. In this study, considering the quality of the data, the Pearson Chi-Square test was used.

Results and Discussion

More than half of the participants in this study had no history of wearing glasses. Also, 57.89% of the participants in this study were women. Based on the Fisher's Exact statistical test, it was determined that there was no significant difference between the two studied groups in terms of gender and history of using glasses ($P > 0.05$) (**Table 1**).

Table 1. The ability to determine the color by gender and the history of using glasses

| Group | Gender | | History of using glasses | | Total (%) |
|-----------------------------------|-------------|-------------|--------------------------|--------------|-------------|
| | Female (%) | Male (%) | Positive (%) | Negative (%) | |
| Training with booklet | 9 (23.68%) | 11 (28.95%) | 10 (26.32%) | 10 (26.32%) | 20 (52.63%) |
| Practical training | 13 (34.23%) | 5 (13.16%) | 7 (18.42%) | 11 (28.95%) | 18 (47.27%) |
| Total | 22 (57.89%) | 16 (42.11%) | 17 (44.74%) | 21 (55.26%) | 38 (100%) |
| The result of Fisher's Exact test | P = 0.112 | | P = 0.532 | | |

There was no significant relationship between training with both practical methods and pamphlets in the improvement of color determination by students. There was no significant difference between the type of training provided to the participants and the correct ratio of determining the color of the first (B4), second (D4), and third (A2) samples ($P > 0.05$). However, the training group with the booklet was significantly more successful in determining the color of the fourth tooth sample (C2) ($P = 0.003$). However, in none of the studied groups and any of the color samples used, the results one month after the training were not better than the results before the training. Also, there was no significant relationship between the accuracy of color determination with the gender of students and the use of glasses ($P > 0.05$). However, in the second color sample (D4), female students performed significantly better ($P = 0.036$).

In total, it was found that the color determination of all four samples, except for the fourth color sample (C2), in the training group with pamphlets and practical training, had no

significant difference, and both types of training were useful in color determination. Only in the sample of the fourth color, teaching with a pamphlet has had better results, which is discussed in the discussion. In all color samples, after one month, the accuracy of color determination has decreased.

Gender and the use of prescription glasses did not have a significant effect on determining the color, and male and female people, those wearing glasses and those without glasses, performed the same in determining the color.

In this study, the effect of two educational methods, including practical training and by handbook, on the ability to determine the color of clinical course students before training, immediately after training, and 1 month after training, considering gender and history of using glasses, was investigated and compared.

Color selection by eye is the most common method of color matching in dentistry [12, 14, 16-18]. To determine color

based on visual evaluation and using color guides, principles have been determined [19]. The clinical color selection process requires the use of a color guide, the most famous of which is the Vita Shade Guide [20].

Although various tools and equipment are available to increase the clinical success in the color selection process, visual selection is still a common method despite being subjective and uneven due to the influence of factors such as age, sex, experience, visual impairment training, and fatigue of the eye receptors [19].

Due to the possibility of being affected by the determination and perception of tooth color by gender, gender differences were investigated in this study. In many studies, the influence of gender on the ability to determine tooth color has been investigated, but there is no general agreement in this field [21].

In the present study, it was found that, except for the training group with the booklet about determining the color of the second sample, there is no significant difference between gender and the correctness of the answer in other groups. The second color sample, which was selected from the classic Vita color guide series, was sample C2, in the current study, 59.26% of the women in the training group with the booklet recognized it correctly, while this percentage was only 30% in the men's group, and a statistically significant difference was observed ($P=0.036$). Also, although women gave better answers than men in the practical group, it did not reach a statistically significant level.

These results are consistent with the study of Nakhaei *et al.* [22] who did not observe any difference between the ability to distinguish Vita colors in different genders. Also, in the studies of Curd *et al.* [23], it was shown that dental students have no significant gender differences in terms of their ability to choose tooth color. In the study of Daneshkazemi *et al.* [24], there was no statistically significant difference in the ability to correctly choose all the colors of the test in the examined men and women. In some studies, it has been reported that women have better color perception, especially in the red and green ranges, while men have a higher ability to perceive brightness and darkness [25].

Carsten suggests that people who do not have the right color choice have a color vision disability. All men suffer from this disorder to some extent, i.e. color vision confusion, which may be temporary or permanent [26]. Based on the study and available information, compared to the male gender, due to the way inheritance of genes related to the occurrence of color-sensitive cells in the retina, females are probably more capable in terms of color vision [3]. Also, Haddad *et al.* [27] in their research concluded that women had a better choice of color compared to men.

Despite this, in the study of Gharemanloo *et al.* [28], male students compared to female students showed a higher

percentage of repeatability while using both color guide systems, although this issue was not statistically significant and needs further study. In our study, it was found that a high percentage of students who participated in this study recognized the color sample correctly, but no significant effect was observed despite the practical training or using the pamphlet. Results did not follow the same pattern between different color samples. For example, in the first color sample, B4 was selected, a high percentage of participants recognized the color correctly at the beginning of the study. This ratio decreased after the pamphlet training and after one month after the practical training, despite the initial increase. Similar results were observed in other color samples.

It should also be mentioned that one of the interesting results of this study was that in none of the studied groups and any of the color samples used, the results one month after the training were not better than the results before the training. This means that even if in some cases training has increased the percentage of determining the correct color in the short term, it has never had a positive effect in the long term. These findings are consistent with the study of Della Bona *et al.*

In the present study, a comparative study was also done between the two methods of teaching with pamphlets and practical training. Although in all samples of determined colors, better results were observed in the group trained with the booklet than in the practical training group, only in the case of the fourth color sample (C2) there was a significant difference. In other color samples, the difference was not statistically significant. In this field, no similar study had been done to compare the results, however, it seems that due to the possibility of revisiting the teaching method with pamphlets, probably due to the lack of acceptance and patience of students to participate in face-to-face training in addition to Classrooms, the teaching method with pamphlets can be considered a more efficient method for dental students.

In the study of Alfouzan *et al.* it was found that training and practice on color selection can play an important role in the accuracy of color determination. Gharemanloo *et al.* [28] point out that clinicians compared to students, and students compared to nurses, have a better understanding and efficiency in the field of applying common methods of color selection, and this indicates that adjustment courses Training is useful for improving understanding and working methods in this field. In our study, the history of using glasses was investigated as a possible influencing factor in the ability to determine color. Except in the first color sample (D4) where people without a history of wearing glasses performed better, in other color samples, people who had a history of wearing glasses performed better, although there was no significant difference in any of the color samples. It did not ($P<0.05$). These findings seem to be a sign of mild vision problems that exist in many people who

are unaware of it or do not see the need to correct it because it does not interfere with their daily lives and work.

Conclusion

According to the results of this study, it can be said that pamphlet training has a greater role in improving the accuracy of color determination than practical training for dental students. On the other hand, the use of glasses and gender did not have a significant effect on the accuracy of determining the color of the selected samples in this study. Among the limitations of the present study, we can point out the lack of examination of the experience factor in the accuracy of color determination, the lack of use of other available educational methods, and the conduct of this study in vitro, which is suggested to be included in future studies.

Acknowledgments: None

Conflict of interest: None

Financial support: None

Ethics statement: None

References

1. Sturdevant CM, Roberson TM, Heymann HO, Sturdevant JR. The art and science of operative dentistry. 4th Ed. St. Louis: The C.V Mosby Co. 2001.
2. Ritter AV, Walter R, Boushell LW, Ahmed SN. Clinical technique for direct composite resin and glass ionomer restorations. In Sturdevant's Art and Science of Operative Dentistry 2018 Jan 1 (pp. 219-263). Elsevier.
3. Fondriest J. Shade matching in restorative dentistry: The science and strategies. *Int J Periodontics Restorative Dent.* 2003;23(5):467-79.
4. Alnusayri MO, Sghaireen MG, Mathew M, Alzarea B, Bandela V. Shade selection in esthetic dentistry: A review. *Cureus.* 2022;14(3):e23331. doi:10.7759/cureus.23331
5. Jouhar R, Ahmed MA, Khurshid Z. An overview of shade selection in clinical dentistry. *Appl Sci.* 2022;12(14):6841. doi:10.3390/app12146841
6. Sikri VK. Color: Implications in dentistry. *J Conserv Dent.* 2010;13(4):249-55. doi:10.4103/0972-0707.73381
7. Okubo SR, Kanawati A, Richards MW, Childress S. Evaluation of visual and instrument shade matching. *J Prosthet Dent.* 1998;80(6):642-8.
8. Morsy N, Holiel AA. Color difference for shade determination with visual and instrumental methods: A systematic review and meta-analysis. *Syst Rev.* 2023;12(1):95. doi:10.1186/s13643-023-02263-9
9. Vohra M, Shenoy A. In vitro evaluation of accuracy and reliability of tooth shade selection using different digital instruments. *Cureus.* 2024;16(1):e52363. doi:10.7759/cureus.52363
10. Geary JL, Kinirons MJ. Use of a common shade guide to test the perception of differences in the shades and value by members of the dental team. *Prim Dent Care.* 1999;6(3):107-10.
11. Elamin HO, Abubakr NH, Ibrahim YE. Identifying the tooth shade in group of patients using Vita Easyshade. *Eur J Dent.* 2015;9(2):213-7. doi:10.4103/1305-7456.156828
12. Brewer JD, Wee A, Seghi R. Advances in color matching. *Dent Clin North Am.* 2004;48(2):341-58.
13. Hardan L, Bourgi R, Cuevas-Suárez CE, Lukomska-Szymanska M, Monjarás-Ávila AJ, Zarow M, et al. Novel trends in dental color match using different shade selection methods: A systematic review and meta-analysis. *materials (Basel).* 2022;15(2):468. doi:10.3390/ma15020468
14. Corcodel N, Karatzogiannis E, Rammelsberg P, Hassel AJ. Evaluation of two different approaches to learning shade matching in dentistry. *Acta Odontol Scand.* 2012;70(1):83-8. doi:10.3109/00016357.2011.600705
15. Žarko U, Hrvoje P, Robert Ć. Gender-dependent quality of shade matching of dental professionals and students. *Acta Stomatol Croat.* 2020;54(4):363-70. doi:10.15644/asc54/4/3
16. Van der Burgt TP, Ten Bosch JJ, Borsboom PC, Plasschaert AJ. A new method for matching tooth colors with color standards. *J Dent Res.* 1985;64(5):837-41.
17. Arenas AA, Gallardo CA, Osorio VC. Selection of tooth colour using spectrophotometry and a visual method. A literature review. *J Oral Res.* 2021:1-4. doi:10.17126/joralres.2021.041
18. Oh WS, Pogoncheff J, O'Brien WJ. Digital computer matching of tooth color. *Materials.* 2010;3(6):3694-9. doi:10.3390/ma3063694
19. Capa N, Malkondu O, Kazazoglu E, Calikkocaoglu S. Evaluating factors that affect the shade-matching ability of dentists, dental staff members and laypeople. *J Am Dent Assoc.* 2010;141(1):71-6.
20. Paravina RD, Powers JM. Esthetic color training in dentistry. (No Title). 2004.
21. Hamad IA. Intrarater repeatability of shade selection with two shade guides. *J Prosthet Dent.* 2003;89(1):50-8.
22. Nakhaei M, Ghanbarzadeh J, Keyvanloo S, Alavi S, Jafarzadeh H. Shade matching performance of dental students with three various lighting conditions. *J Contemp Dent Pract.* 2013;14(1):100-3.
23. Curd FM, Jasinevicius TR, Graves A, Sadan A. Comparison of the shade matching ability of dental students using two light sources. *J Prosthet Dent.* 2006;96(6):391-6.
24. Daneshkazemi A, Besharati MR, Davari A. Assessment of color matching ability among the student of Yazd faculty of dentistry. *J Dent Sch.* 2008;26(1):40-6.
25. Murray IJ, Parry NR, McKeefry DJ, Panorgias A. Sex-related differences in peripheral human color vision: A color matching study. *J Vis.* 2012;12(1):18.

26. Carsten DL. Successful shade matching--what does it take? *Compend Contin Educ Dent.* 2003;24(3):175-8, 180, 182 passim; quiz 188.
27. Haddad HJ, Jakstat HA, Arnetz G, Borbely J, Vichi A, Dumfahrt H, et al. Does gender and experience influence shade matching quality? *J Dent.* 2009;37 Suppl 1:e40-4.
28. Ghahramanloo A, Goharian R, Esmaeeli H. Evaluation of shade selection repeatability with vita-classic & 3dmaster by two groups of male and female students of Mashhad Dental School. *J Mash Dent Sch.* 2008;32(3):213-20.