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ORIGINAL RESEARCH ARTICLE

Comparison of the Effectiveness of Theoretical Learning and Dental Anesthesia Simulator in Dental Education

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Abstract

Purpose: This study aims to compare the effectiveness of theoretical and hands-on teaching methods in preclinical settings, specifically evaluating the impact of video conference training versus dental simulator-based training on clinical skills during the preclinical phase, as well as assessing the effects of theoretical education versus practical application on learning outcomes.
Materials and Methods: This study is a prospective, randomized investigation comparing the contributions of video conference training and Nissin dental simulator communication-based training methodologies to the practical training competence of dental students at two different institutions. Participants were then randomly divided into two groups based on the learning style to be applied. Each student was asked to respond to a questionnaire consisting of ten questions assessing changes in their learning capacities before and after the training. The responses were subsequently compared within and between the two different learning styles. Independent t-tests were conducted to compare the measurements between the universities, while paired t-tests were applied to evaluate the pre- and post-test scores of learning styles within each university.
Results: No statistically significant increase in learning outcomes was observed among students utilizing the video conference learning method at either institution. Conversely, students engaged in Nissin dental simulator communication-based teaching methods demonstrated a statistically significant increase in learning outcomes, both compared to their prior performance and to those receiving video conference training. While no differences were observed between the learning styles within either institution, students at Bolu Abant Izzet Baysal University exhibited a greater increase in learning outcomes compared to those at Ankara Yildirim Beyazit University, receiving video conference training.
Conclusions: This study demonstrates that preclinical dental simulation training is more effective than video-conference-based instruction in enhancing dental students' knowledge of anatomy and anesthesia, as well as their clinical skills. These findings highlight the importance of integrating simulation-based methodologies more extensively into dental curricula, particularly in contexts where traditional patient-centered learning opportunities are limited.

Keywords: Dental; Education; Simulation

Introduction

Learning is a lifelong process that involves acquiring new knowledge, values, and skills as a result of knowledge accumulation. Education refers to the process carried out by an educator during a specific period in life, primarily focused on imparting information.[1] Learning style encompasses behavioral characteristics that learners use as cognitive, affective, and psychological determinants, relatively stable in terms of perception, interaction, and response within learning environments.[2] It has been suggested that a teaching process compatible with students' learning styles fosters positive behaviors towards instruction, enhances effective learning, and contributes to academic success. Assessing learning styles is crucial for understanding how individuals learn and determining the appropriate design and environment for teaching.[3]

Traditional education systems, where the educator instructs and the student passively listens without feedback, are being replaced by learner-centered approaches that employ modern auditory and visual educational tools, demonstrating how students can access knowledge.[4] The one-on-one patient-centered training method for dental students plays a key role in skill acquisition.[5] Simulation-based modern medical and dental education methods have become significant components of technology-assisted education.[6] Current and anticipated approaches to dental education have sparked widespread interest in clinical simulation, leading to a notable increase in the availability of experiential tools that mimic "real-life"

clinical conditions.[7] Different simulation models used in dental education include traditional laboratory mannequins mounted on metal rods, contemporary simulation clinics, and virtual reality or computer-assisted simulation clinics.[8] Compared to traditional educational methods, existing simulation-based training systems enhance learning by transitioning educational settings from traditional classrooms to virtual environments, thereby increasing student engagement. Furthermore, these methods allow for the repeated application and assessment of specific skills.[9] However, unlike conventional teaching methods, laboratory simulation training tends to be more expensive.[10] Therefore, it is essential not to confine education to theoretical and communicative processes alone; a balanced teaching design should integrate both synchronous and asynchronous simulation applications.

The hypothesis of this study was that dental simulator–based training is more effective than video-conference–based theoretical instruction in enhancing both the knowledge and clinical skills of dental students during the preclinical phase of dental education. Preclinical dental education provides the foundation for developing clinical competence, especially in core areas such as anatomy and local anesthesia, which are vital for patient safety and effective treatment. The teaching strategies applied at this stage can greatly affect students' readiness for clinical practice. Simulation-based training allows students to build clinical skills without risk to patients and supports the integration of theoretical knowledge with hands-on learning. Recent studies indicate that dental students find haptic VR simulators highly beneficial for improving manual skills and regard them as effective complements to traditional preclinical education.[11–15] However, only a limited number of studies have compared the outcomes of simulator-based training with a physical dental anesthesia model to video-conference–only teaching, particularly regarding both knowledge and practical skill development. The aim of this study was to evaluate the comparative effectiveness of two different learning methods: theoretical instruction delivered solely through video conferencing, and practice-based instruction utilizing the Nissin dental simulator.

Material and Methods

Ethical approval was obtained from the Clinical Research Ethics Committee of Ankara Yıldırım Beyazıt University (Approval no. 475/48-2019). Conducted concurrently during the 2019-2020 academic year at Ankara Yildirim Beyazit University and Bolu Abant Izzet Baysal University, the study involved preclinical third-year students pursuing basic dental education. Written informed consent was obtained from all participants prior to their inclusion in the study. All students first attended a 45-minute lecture covering key anatomical landmarks and anesthesia techniques (Table 1). The introductory lesson encompassed a brief demonstration of visual anatomy and direct examination of the anatomical points listed in Table 1. Following this, students underwent a multiple-choice test, with those achieving a score of 70 or above included in the study. Students possessing a shared foundational knowledge base were randomly assigned to two study groups (Group A and Group B), each consisting of 40 participants, without discrimination based on the chosen training method (video conference-supported visual training for Group A and Nissin dental simulator-based communication training for Group B). In this study, students from two different universities were divided into four groups to evaluate the effect of theoretical and practical training on their learning of dental anesthesia techniques. Group A comprised students whose learning outcomes were assessed prior to receiving a theoretical video-conference-based training, whereas Group A' included those whose knowledge was assessed following the theoretical instruction. Group B consisted of students evaluated before receiving practical training using a dental simulation model, while Group B' comprised those assessed after completing the simulation-based practical training.

Table 1. Identifying the characteristics of anesthesia application techniques and evaluation of anatomical points in the multiple choice test exam

ANATOMIC LANDMARKS
1-Foramen mandibularis
2-Foramen p. majus
3-Mental foramen
4- Infraorbital foramen
5-Foramen incisivus
IMPLEMENTATION CRITERIA
1- Nervus alveolaris inferior
2- Nervus maxillaris
3- Nervus mentalis
4- Nervus infraorbitalis
5-Nervus incisivus
BASIC INJECTION TECHNIQUES
Anatomical evaluation for local anesthesia
Maxillary anesthesia techniques
Mandibular anesthesia techniques I
Mandibular anesthesia techniques II

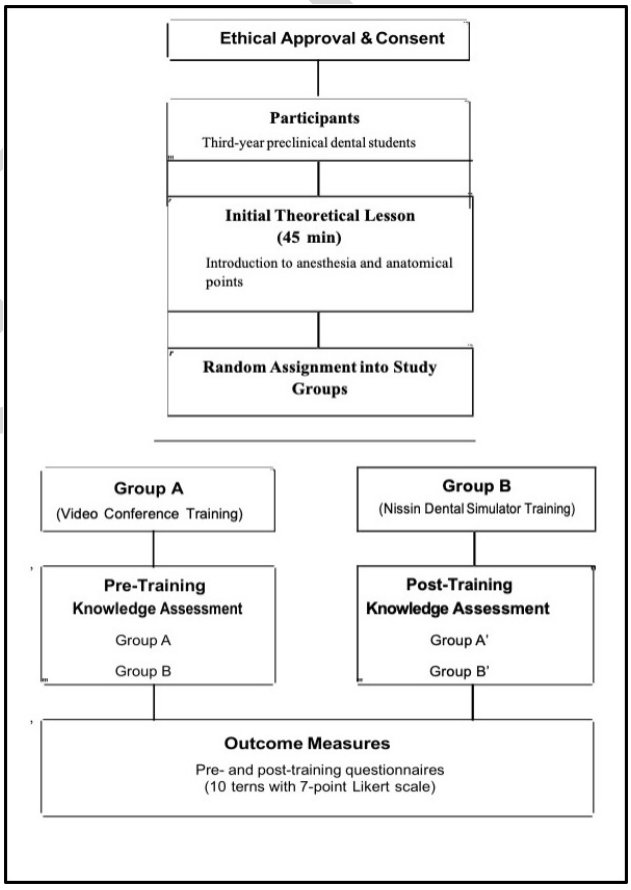

Figure 1. A flowchart of the study design shows methodology

The flow chart of the study design has been added as Figure 1.

This study utilized a Nissin dental simulation model mounted on metal rods (CAM SUG2005-UL-SP; Nissin Dental Products, Kyoto, Japan) (Figure 2). The simulators feature 32 anatomically shaped teeth and 11 anesthetic contact sensor points (seven in the upper jaw and four in the lower jaw), equipped with auditory and visual indicators confirming correct positioning and angle. Students in both groups completed a pre- and post-training questionnaire consisting of ten questions measuring attitudes, knowledge, and skill levels. Based on their learning outcomes, students were asked to respond using a 7-point Likert scale, ranging from 0 (very poor) to 7

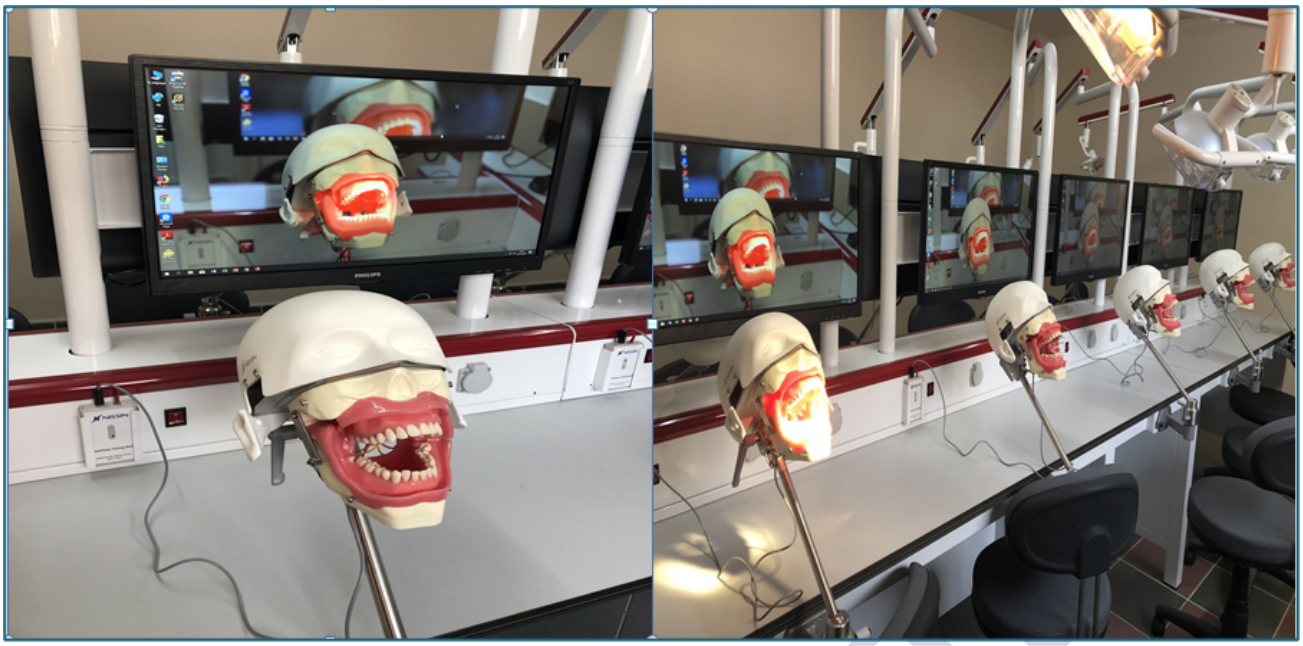

Figure 2. NISSIN Computer-Aided Dental Simulator

(very good), to express their opinions on anatomical formations, interpretation of anatomical regions, recognition of anesthesia technique characteristics, and clinical skills based on the taught materials (Table 2,3,4,5). Following the questionnaire, Group A received video conference training (computer-assisted visual training using visual slides), while Group B underwent Nissin dental simulator simulation-based training. Finally, students were asked to respond to the same ten questions post-training to assess changes in their learning outcomes and the differences between the two learning techniques.

Statistical analysis

This study, aimed at examining the impact of two different learning styles, specifically Video Conference and Nissin dental simulator communication-based teaching methodologies across two universities, calculated the sample size with a power of at least 0.80 and a Type I Error rate of 0.05. Descriptive statistics for continuous variables were expressed as Mean, Standard Deviation, Minimum, and Maximum. Shapiro-Wilk ($n<50$) and Skewness-Kurtosis tests were used to determine whether the continuous measurement averages were normally distributed, and parametric tests were applied due to normal distribution. Independent T-tests were employed to compare measurements between universities, while Paired T-tests were calculated for the pre- and post-scores of learning styles applied separately at each university. A statistical significance level (α) of 5% was adopted, with calculations performed using SPSS (IBM SPSS for Windows, ver.24) statistical software (Table 6).

Results

Intra-University Comparison Results

At Ankara Yildirim Beyazit University, no statistically significant difference was observed between Group A and Group A' (pre- and post-video conference training) scores ($p>0.05$). Likewise, no significant increase was noted in Group A' (post-video conference training) scores. However, a statistically significant change was detected between Group B and Group B' (pre- and post-Nissin dental simulator simulation-based training) scores at Ankara Yildirim Beyazit University ($p<0.05$), indicating a significant increase in Group B' scores. Furthermore, a statistically significant difference was identified between Group A' and Group B' (post-video conference training vs. post-Nissin dental simulator simulation-based training) scores ($p<0.05$), with Group B' (post-Nissin dental simulator simulation-based training) scores exceeding those of Group A' (post-video conference training).

Similarly, at Bolu Abant Izzet Baysal University, no statistically significant difference was found between Group A and Group A' (pre- and post-video conference training) scores ($p>0.05$), and no significant increase was observed in Group A' scores. Nevertheless, a statistically significant change was recorded between Group B and Group B' (pre- and post-Nissin dental simulator simulation-based training) scores at this university ($p<0.05$), reflecting a significant increase in Group B' scores. A statistically significant difference was also found between Group A' and Group B' scores at Bolu Abant Izzet Baysal University ($p<0.05$), with Group B' scores being higher than those of Group A'.

Inter-University Comparison Results

No statistically significant difference was observed between the pre-video conference training scores of Group A across the two universities ($p>0.05$), indicating that the Group A scores do not vary by university. However, a statistically significant difference was noted between the post-video conference training scores of Group A (A' Group) across the two institutions ($p<0.05$), indicating variability. Specifically, the "A' Group score" at Bolu Abant Izzet Baysal University was significantly higher than that at Ankara Yildirim Beyazit University. The pre- and post-Nissin dental simulator simulation-based training scores of Group B did not show a statistically significant difference across the two universities ($p>0.05$). However, a significant difference was noted in the post-scores of the Nissin dental simulator simulation-based training of Group B (B' Group) across the universities ($p<0.05$), with the B' Group score at Bolu Abant Izzet Baysal University being statistically higher than that at Ankara Yildirim Beyazit University.

Table 2. Responses of Group A, were assessed prior to receiving theoretical training via video conference, using a 7-point Likert scale to evaluate perceptions of clinical skills related to local anesthesia applications

GROUP A								
Questions	Very Good (7 points)	Good (6 points)	Somewhat Good(5 points)	Somewhat Bad(4 points)	Bad (3 points)	Very Bad (2 points)	Undecided (1 point)	Total
Understanding of Basic Injection Techniques	0	2	6	4	2	1	1	69
Understanding of Local Anesthesia Techniques	0	3	5	4	2	1	1	68
Ability in Maxillary Anesthesia Techniques	0	3	6	2	3	1	1	70
Understanding of Mandibular Anesthesia Techniques	0	3	5	3	3	1	2	70
Confidence in Patient Approach	0	2	6	4	2	1	1	69
Attention Level in Treatment Application	1	4	6	2	1	1	1	65
Knowledge Increase Compared to Pre-Education	2	4	4	2	2	1	1	75
Practical Approach Ability Post-Education	2	2	4	4	1	1	2	72
Ability for Quick Decision and Application in Treatment Approach	0	3	6	3	0	1	3	65
Anxiety Level Regarding Complication-Related Errors	2	3	3	2	3	1	2	68
TOTAL	49	174	255	120	57	20	15	

Table 3. Responses of Group A', were assessed after receiving theoretical training via video conference, using a 7-point Likert scale to evaluate perceptions of clinical skills related to local anesthesia applications

GROUP A'								
Questions	Very Good (7 points)	Good (6 points)	Somewhat Good(5 points)	Somewhat Bad(4 points)	Bad (3 points)	Very Bad (2 points)	Undecided (1 point)	Total
Understanding of Basic Injection Techniques	1	3	4	3	1	1	1	63
Understanding of Local Anesthesia Techniques	2	3	4	2	1	2	0	67
Ability in Maxillary Anesthesia Techniques	1	3	3	4	1	2	0	63
Understanding of Mandibular Anesthesia Techniques	1	4	4	3	1	0	1	67
Confidence in Patient Approach	2	3	3	2	1	2	1	63
Attention Level in Treatment Application	3	4	2	1	3	1	0	70
Knowledge Increase Compared to Pre-Education	4	4	1	4	1	0	0	66
Practical Approach Ability Post-Education	4	7	3	0	0	0	0	85
Ability for Quick Decision and Application in Treatment Approach	3	6	4	0	1	0	0	80
Anxiety Level Regarding Complication-Related Errors	4	4	2	2	1	1	0	75
Total	205	246	150	84	33	18	3	

Table 4. Responses of Group B were assessed prior to receiving practical training using a dental simulation model, using a 7-point Likert scale to evaluate perceptions of clinical skills related to local anesthesia applications

	GROUP B							
Questions	**Very Good (7 points)**	**Good (6 points)**	**Somewhat Good(5 points)**	**Somewhat Bad(4 points)**	**Bad (3 points)**	**Very Bad (2 points)**	**Undecided (1 point)**	**Total**
Understanding of Basic Injection Techniques	0	5	2	4	3	4	3	**76**
Understanding of Local Anesthesia Techniques	1	2	3	3	7	4	1	**96**
Ability in Maxillary Anesthesia Techniques	1	2	1	5	5	3	4	**69**
Understanding of Mandibular Anesthesia Techniques	1	1	3	4	6	3	3	**71**
Confidence in Patient Approach	3	1	4	4	3	3	4	**82**
Attention Level in Treatment Application	1	2	4	4	3	3	4	**74**
Knowledge Increase Compared to Pre-Education	2	2	5	4	4	2	2	**85**
Practical Approach Ability Post-Education	1	3	4	4	3	3	3	**79**
Ability for Quick Decision and Application in Treatment Approach	1	2	3	3	3	2	4	**63**
Anxiety Level Regarding Complication-Related Errors	3	2	4	3	2	5	2	**83**
Total	98	132	165	152	117	64	30	

Table 5. Responses of Group B' were assessed after receiving practical training using a dental simulation model, using a 7-point Likert scale to evaluate perceptions of clinical skills related to local anesthesia applications

	GROUP B'							
Questions	**Very Good (7 points)**	**Good (6 points)**	**Somewhat Good(5 points)**	**Somewhat Bad(4 points)**	**Bad (3 points)**	**Very Bad (2 points)**	**Undecided (1 point)**	**Total**
Understanding of Basic Injection Techniques	2	6	7	3	2	1	0	**105**
Understanding of Local Anesthesia Techniques	4	6	5	4	1	0	1	**109**
Ability in Maxillary Anesthesia Techniques	4	4	6	3	1	1	1	**100**
Understanding of Mandibular Anesthesia Techniques	3	5	7	3	1	1		**103**
Confidence in Patient Approach	6	5	6	1	1	1	1	**112**
Attention Level in Treatment Application	8	4	6	3		0	1	**123**
Knowledge Increase Compared to Pre-Education	7	7	5	1	1	0	1	**124**
Practical Approach Ability Post-Education	3	3	2	4	3	2	4	**80**
Ability for Quick Decision and Application in Treatment Approach	1	2	6	5	3	1	3	**83**
Anxiety Level Regarding Complication-Related Errors	2	3	5	4	2	4	1	**88**
TOTAL	294	270	270	124	45	22	13	

Table 6. Comparison of the statistical results of measurements by "Intra-University and Inter-University"

	Ankara Yildirim Beyazit University				Bolu Abant Izzet Baysal University				*p.
	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.	
A	74,90	8,58	67,00	91,00	69,10	3,00	65,00	75,00	,059
A'	78,40	3,63	75,00	84,00	69,90	7,68	63,00	85,00	**,005**
**p.		,172				,777			
B	78,00	9,48	64,00	96,00	77,80	9,37	63,00	96,00	,963
B'	105,80	16,52	85,00	135,00	102,70	15,36	80,00	124,00	,669
**p.		**,001**				**,001**			
A'	78,40	3,63	75,00	84,00	69,90	7,68	63,00	85,00	
B'	105,80	16,52	85,00	135,00	102,70	15,36	80,00	124,00	
***p.		**,001**				**,001**			

*Inter-University Comparison (Independent T-test) **Intra-University Before-After Comparison (Paired T-test) ***Intra-University A'-B' Comparison (Independent T-test)

Discussion

This study compared video conference and Nissin dental simulator simulation-based training across two universities. Video conference training did not significantly improve Group A scores, whereas simulator-based training led to significant gains in Group B scores, with Group B outperforming Group A post-training. Inter-university comparisons revealed similar baseline scores but higher post-training improvements at Bolu Abant Izzet Baysal University, suggesting possible contextual or implementation differences. Traditional lectures effectively inform students about concepts and explanations; however, they have limitations in capturing students' attention and in facilitating the learning of practical applications in clinical practice. Learning supported by practical application aids in the development of professional skills in preclinical settings.[16] The constraints of a time-limited curriculum and increasingly complex surgical techniques make it challenging for students to achieve the necessary high level of psychomotor skills in a short timeframe. Thus, there is a need to develop both theoretical and practical teaching methods to enhance effective learning and the acquisition of practical knowledge and skills in dental education. Updating educational techniques and methods could be a means to increase efficiency in surgical training. To ensure low error rates and high success rates in treatments, educational clinical devices that enhance learning and skill acquisition, such as tools and diagnostic methods that allow for various practical applications, are increasingly being utilized.[17] In today's context, technology has enabled simulation to become an experiential learning method that closely mirrors real-life situations. In this regard, dental simulations are defined as systems that replicate the clinical conditions of dental practices and allow for their repeated application.[9] A study by Marei et al.[8] assessed the effectiveness of simulation-based teaching methods for local anesthesia compared to traditional lecture methods among students who had not yet entered clinical practice. Similar to this study's findings, participants in the simulation laboratory group scored significantly higher on a 15-question multiple-choice test compared to those in the traditional lecture group.

Regarding local anesthesia education strategies, Brand et al.[18] evaluated how local anesthesia training is implemented in schools across Europe, noting that most institutions taught both theoretical and practical components of local anesthesia through textbooks, while very few employed preclinical simulation methods.[9] In a study conducted by Lee et al.[19], students were given their first anesthesia experience, with one group receiving simulation training and the other not. The study reported positive effects of simulation training prior to the students' first local anesthesia experience. Reviews of the effectiveness of simulations indicate that simulation-based teaching allows for learning through doing, converting abstract knowledge into concrete experiences, and helping students construct their own understanding. The competence of physicians in patient examination and treatment is critical for the accurate diagnosis and treatment of numerous medical conditions. Therefore, particularly in surgical education, a training curriculum should be structured around competencies in skills, knowledge, and professional attitudes, with "patient safety" as a fundamental element. There is a need for a range of educational materials designed for medical students who may be reluctant to participate in surgical education and training. The increasing number of medical students today limits opportunities for one-on-one education alongside patients. Consequently, adopting a blended learning approach that includes multimedia, e-learning, pre-prepared materials for case-based discussions, and instructor notes has become essential. Theoretical education and preclinical dental learning aim for a gradual acquisition of clinical competence through practical training. Students enhance their knowledge based on clinical observation and practice during both undergraduate and specialty training. Therefore, it is crucial to continually improve teaching techniques.

Adequate preclinical surgical training must ensure the assessment and development of dental students' knowledge and clinical skills before their application on patients. However, there is a lack of comprehensive studies directly evaluating subjective and objective parameters comparing interactive demonstration training with traditional lectures in undergraduate education.[15] This study, which evaluated the use of interactive systems in clinical training for dental students, supports simulation-based learning styles. Students' learning capabilities in physical examination, communication skills, decision-making, and role modeling occur through interaction with patients. Thus, finding strategies to enhance knowledge, skills, and attitudes before clinical education is of great importance. This study demonstrates that educational strategies that mimic clinical settings will improve the quality of students' treatment skills. This not only enhances the acquisition of knowledge and skills but also ensures that more qualified physicians provide better services to society. Thanks to these new technological applications, students receive instant feedback and have the opportunity to correct potential mistakes during the process. This interactive teaching system includes elements supported by theory for learning and model-supported demonstration elements for practice, thereby allowing for the rapid querying and assessment of students' knowledge. To date, there has not been sufficient research in the field of dentistry examining how interactive communication affects the success of the teaching process. Therefore, the aim of this study was to evaluate two different preclinical teaching models. The primary goals in introducing this methodology are to offer an interactive and applied teaching system on lifelong anatomical models and to directly compare this approach with traditional teaching/learning methods. Additionally, it contributes to the analysis of individual learning styles, increases interactive student engagement in educational methods, and ultimately leads to improvements in both qualitative and quantitative parameters of knowledge transfer. The use of head and neck anatomy models as a learning tool helps students comprehend complex medical data and provides opportunities to capture and evaluate metrics of knowl-

edge transfer. Several limitations should be acknowledged. First, the sample size was relatively small, which may limit the generalizability of the findings. Second, the study assessed only immediate post-training performance, so long-term retention application of skills was not evaluated. Third, differences between universities in teaching environments or instructor experience may have affected results. Finally, the observed results may have been influenced by uncontrolled factors, such as individual participation levels during training.

In this study, the effectiveness of two different teaching methods concerning anatomy and anesthesia courses for preclinical dental students was compared, revealing that Nissin dental simulation training resulted in a higher level of knowledge compared to video conference training at both educational institutions. It was determined that the increase in knowledge following video conference training was significantly higher at Bolu Abant Izzet Baysal University compared to Ankara Yildirim Beyazit University. This is thought to be due to variations in teaching techniques, despite the similarity of the video conference training. Following Nissin dental simulation training, significant increases were observed in both institutions, with no differences between them. This indicates that Nissin dental simulation training is a more stable method, suggesting that, although there may be differences between educators and institutions, it can be more easily standardized.

Conclusion

The study concludes that direct preclinical dental simulation training is more effective than video conference training in improving dental students' understanding of anatomy and anesthesia, as well as their clinical skills. These findings advocate for the inclusion of more simulation-based methodologies in dental education, particularly when traditional patient-centered training opportunities may be limited.

Ethical Approval

The institutional ethical committee approval was obtained (approval number: 475/48-2019). This study was performed in line with the principles of the Declaration of Helsinki.

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Author Contributions

Design : All Authors
Data Collection : N.A.
Data Analysis and Led the Writing: All Authors

Conflict of Interest

The authors declare no competing interests.

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References

1. Büyükdere AK. DİŞ HEKİMLİĞİ FAKÜLTESİ ÖĞRENCİLERİNİN ÖĞRENME STİLLERİNİN İKİ FARKLI YÖNTEMLE ANALİZİ. Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi. 2018;28(3):371–376. doi:10.17567/ataunidfd.473299.
2. Keefe JW, Ferrell BG. Developing a Defensible Learning Style Paradigm. Educational leadership. 1990;48(2):57–61.
3. Kazanci F, Kazancı E, Memduhoğlu H, Sevimli S. TIP VE DİŞ HEKİMLİĞİ FAKÜLTESİ ÖĞRENCİLERİNİN ÖĞRENME STİLLERİNİN KARŞILAŞTIRILMASI. Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi. 2015;24(1). doi:10.17567/dfd.33658.
4. Peker T, Gülekon IN, Özkan S, Anıl A, Turgut HB. Karmaşık anatomik yapıların üç boyutlu anaglif stereo yöntemi kullanılarak öğrencilere anlatılması ve bunun geleneksel iki boyutlu ders anlatımı ile karşılaştırılması. Acta Odontologica Turcica. 2014;31(2):80–3. doi:10.17214/aot.06914.
5. Suvinen TI, Messer LB, Franco E. Clinical simulation in teaching preclinical dentistry. European Journal of Dental Education. 1998;2(1):25–32. doi:10.1111/j.1600-0579.1998.tb00032.x.
6. Çinici A, Özden M, Akgün A, Ekici M, Yalçın H. Sanal Ve Geleneksel Laboratuvar Uygulamalarının 5. Sınıf Öğrencilerinin Işık Ve Ses Ünitesiyle İlgili Başarıları Üzerine Etkisinin Karşılaştırılması. Bayburt eğitim fakültesi dergisi. 2013;8(2):92–106.
7. Perry S, Bridges SM, Burrow MF. A review of the use of simulation in dental education. Simulation in Healthcare. 2015;10(1):31–37. doi:10.1097/SIH.0000000000000059.
8. Marei H, Al-Jandan B. Simulation-based local anaesthesia teaching enhances learning outcomes. European journal of dental education. 2013;17(1):e44–e48. doi:10.1111/j.1600-0579.2012.00760.x.
9. Taner T, Yılmaz Z, Kütük ZB, Küçükkaya Eren S. Diş hekimliği eğitiminde simülasyon uygulamaları. Türkiye Klinikleri J Med Educ Special Topics. 2017;2(2):86–95.
10. Ziv A, Ben-David S, Ziv M. Simulation based medical education: an opportunity to learn from errors. Medical teacher. 2005;27(3):193–199. doi:10.1080/01421590500126718.
11. Daud A, Matoug-Elwerfelli M, Daas H, Zahra D, Ali K. Enhancing learning experiences in pre-clinical restorative dentistry: the impact of virtual reality haptic simulators. BMC Medical Education. 2023;23(1):948. doi:10.1186/s12909-023-04904-y.
12. Hu J, Wang X, Chen R, Lu G, Zhang M, Huang X. Use of virtual simulation for regenerative endodontic training: randomized controlled trial. BMC Medical Education. 2025;25(1):254. doi:10.1186/s12909-025-06808-5.
13. Kary AL, Gomez J, Raffaelli SD, Levine MH. Preclinical local anesthesia education in dental schools: a systematic review. Journal of Dental Education. 2018;82(10):1059–1064. doi:10.21815/JDE.018.106.
14. Koolivand H, Shooreshi MM, Safari-Faramani R, Borji M, Mansoory MS, Moradpoor H, et al. Comparison of the effectiveness of virtual reality-based education and conventional teaching methods in dental education: a systematic review. BMC Medical Education. 2024;24(1):8. doi:10.1186/s12909-023-04954-2.
15. Tang T, Li X, Lin Y, Liu C. Comparing digital real-time versus virtual simulation systems in dental education for preclinical tooth preparation of molars for metal-ceramic crowns. BMC Oral Health. 2025;25(1):814. doi:10.1186/s12903-025-06161-5.
16. Genç H. Uzaktan egitimde kurumsal modeller ve öğrenen destek hizmetleri uygulamaları. Açıköğretim Uygulamaları ve Araştırmaları Dergisi. 2019;5(2):29–48.

17. Gaba DM. The future vision of simulation in health care. Qual Saf Health Care. 2004;13(suppl 1):i2–i10. doi:10.1136/qhc.13.suppl_1.i2.
18. Brand H, Kuin D, Baart J. A survey of local anaesthesia education in European dental schools. European Journal of Dental Education. 2008;12(2):85–88. doi:10.1111/j.1600-0579.2008.00505.x.
19. Lee JS, Graham R, Bassiur JP, Lichtenthal RM. Evaluation of a local anesthesia simulation model with dental students as novice clinicians. Journal of dental education. 2015;79(12):1411–1417. doi:10.1002/j.0022-0337.2015.79.12.tb06040.x.