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Students' perceptions of virtual interactive clinical case-based learning: A comparative study with three different cohorts

Anita Nasseri [a†], Tara Zhou [a†], Vivian Ha [a], Jenna Zhu [a], David Wu [b], Hiroe Ohyama [c*]

[a] Harvard School of Dental Medicine, Boston, MA, USA
[b] Department of Oral Medicine, Infection, and Immunity, Harvard School of Dental Medicine, Boston, MA, USA
[c] Department of Restorative Dentistry and Biomaterials Sciences, Harvard School of Dental Medicine, Boston, MA, USA

Abstract *Background/purpose:* Since the introduction of virtual learning into dental education, students' perceptions of the effectiveness of virtual versus in-person learning formats have evolved for interactive clinical case-based learning (ICCBL). This study aimed to undertake a comparative analysis of three different cohorts that received various formats of ICCBL instruction.
Materials and methods: A survey was distributed to the Classes of 2023, 2024, and 2025 following each class completion of interactive clinical case-based-tutorials (ICCBT) as part of the Treatment of Active Disease (TxAD) course at Harvard School of Dental Medicine.
Results: A total of eighty-five participants from the three cohorts, twenty-three students from the Class of 2023 (virtual format, 71.9 % participation rate), thirty-one students from the Class of 2024 (combination of virtual and in-person, 91.2 %), and thirty-one students from the Class of 2025 (in-person, 83.8 %) completed the post-course survey. Across three classes, all cohorts were more likely to perceive the virtual format as more effective than in-person ICCBT. In addition, the classes were more likely to prefer virtual based classes compared to in-person tutorials in the future.
Conclusion: This study highlights the dynamic shifts in educational approaches to align with the evolving demands of contemporary students. Our findings show that all cohorts expressed a preference for virtual ICCBT sessions and perceived virtual ICCBT sessions as somewhat more effective for learning compared to in-person sessions. These findings challenge the notion that

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* Corresponding author. Harvard School of Dental Medicine, 188 Longwood Ave, Boston, MA, 02115, USA.
E-mail address: hiroe_ohyama@hsdm.harvard.edu (H. Ohyama).
† These authors contributed equally to this work and should be considered co-first authors.

such sessions must be conducted in person, prompting further research and the exploration of potentially more effective and optimized educational methods.

Introduction

In healthcare education, the acquisition of clinical knowledge and experience is only partially achievable through conventional lectures and literature.[1] The limitations of a lecture-centered learning approach become apparent in healthcare professionals, particularly in dentistry, where patient-centered care and procedure-based training are essential.[2,3]

Interactive Clinical Case-based learning (ICCBL) has proven to be an effective and dynamic teaching method in healthcare education, attributed to its active learning components, opportunities for self-study, the cultivation of critical thinking skills, and the enhancement of knowledge retention.[1,4—6] Additionally, ICCBL allows students to apply their knowledge to clinical cases, stepping into the role of the dental care provider. This immersive approach enables students to navigate unexpected complications, financial barriers, intricate patient relations -aspects often overlooked in traditional textbook teaching. By relating information to specific cases or patient scenarios, students are able to understand their patients holistically and make well-informed decisions in diagnosis and treatment planning.[7] The ICCBL not only enhances clinical competence but also fosters a deeper understanding of the patient care process beyond theoretical frameworks.[8—10]

Traditionally, ICCBL sessions have been conducted in person, facilitating direct interaction between educators and students.[5] However, the education landscape is undergoing a significant transformation influenced by the rapid advancement of technology, the integration of artificial intelligence (AI) tools, and the widespread use of social media platforms.[11,12] One such evolution is the incorporation of virtual learning environments, which has revolutionized how students engage with educational content. In this context, ICCBL has transcended physical boundaries, enabling remote student participation, fostering inclusivity, and accommodating flexible schedules as well as diverse learning styles.[13]

Furthermore, the COVID-19 pandemic has accelerated the integration of virtual learning, enabling students to participate in ICCBL remotely.[14] Despite the evident shift towards virtual education, the impact of this fundamental transformation on dental education remains an underexplored area of research. Initially, virtual education faced considerable challenges and met with more negative perceptions.[15—18] Recently, however, both students and faculty's feedback and experiences shifted towards a more positive outlook.[19—22] While numerous studies were conducted to learn the broader impacts on the virtual dental education, the specific effects of the fundamental transformation on ICCBL have not been well studied.

In our previous study, we compared and evaluated student's perceptions and experiences from two cohorts: i) exclusively virtual and ii) a combination of in-person and virtual ICCBL sessions. Interestingly, the study revealed that most students in both cohorts expressed a preference for the virtual ICCBL sessions, despite expressing different formats.[23] Currently, ICCBL sessions are exclusively conducted in person, representing the third cohort. Our study aimed to undertake a comparative analysis, encompassing these three different cohorts, to discern trends over time. Our objective was to understand students' evolving perceptions and experiences regarding the effectiveness of ICCBL when delivered in virtual versus in-person formats.

Materials and methods

The Harvard Longwood Medical Area Office of Human Research Administration (Boston, MA, USA) determined this study met the criteria for exemption according to regulations defined by the U.S. Department of Health and Human Services (IRB20-1177).

Interactive clinical case-based tutorial modules

A total of 103 third-year students, 32 students from the Class of 2023 (Female 68.5 % and male 31.4 %), 34 students from the Class of 2024 (Female 69.7 % and male 30.3 %), and 37 students from the Class of 2025 (Female 67.6 % and male 32.4 %), participated in tutorial sessions based on interactive clinical case-based learning as part of the Treatment of Active Disease (TxAD) course at Harvard School of Dental Medicine (HSDM) over a three-year period. The TxAD course, designed as a multi-disciplinary clinical program which focuses on instructing students in management of active disease. It encompasses a broad spectrum of preclinical and clinical learning and treatment modalities, providing students with a comprehensive and practical understanding of how to address and treat simple to complex cases.

Each class was divided into four interactive clinical case-based tutorial (ICCBT) groups consisting of eight to nine students, each guided by a tutorial leader. The format of ICCBT entailed group discussions of six multidisciplinary cases; the same six cases were used each academic year. Each clinical case featured patient scenarios accompanied by comprehensive clinical photos and radiographs. Tutorial leaders underwent calibration by the course director at the

beginning, middle, and as needed throughout the course. Thorough tutorial guides for tutors were also prepared by appropriate faculty for each case to ensure a consistent clinical-based experience and knowledge across all four groups.

The Class of 2023 exclusively participated in virtual sessions (V-ICCBT cohort), while the Class of 2024 experienced a combination of in-person and virtual sessions (C-ICCBT cohort): primarily in-person but including some supplemental virtual/hybrid sessions to accommodate tutor or students' schedule conflicts or medical conditions. The Class of 2025 had exclusively in-person sessions (I-ICCBT cohort). Zoom (Zoom Video Communications Inc. San Jose, CA, USA) was used for all virtual ICCBT sessions. Students were familiar with the platform through virtual didactic lectures, clinical presentations, or team meetings. For this project, we defined "virtual, all students attend via Zoom", "hybrid, some students attend in-person and others attend virtually", and "in-person, all students attend in-person".

Data collection

Upon the conclusion of the course, students received an anonymous post-course survey in hard copy format each year during an in-person class session. Participation in the survey was voluntary. The first survey was conducted in July 2021, the second survey in June 2022, and the third survey in June 2023, administered to the V-ICCBT, C-ICCBT, and I-ICCBT cohorts, respectively. The aim was to understand students' perceptions and experiences related to learning effectiveness, advantages and disadvantages, and their preferences for instructional formats. The surveys consisted of both closed-ended and open-ended questions. A Likert scale ranging from one to five was used (i.e., 1 = "least effective"; 5 = "most effective", or 1 = "Strongly disagree"; 5 = "Strongly agree").

Each survey included two identical core questions. Additionally, all surveys had open-ended questions related to both current and future ICCBT to collect students' feedback and suggestions (Tables 3a, 3b and 3c). For the second survey, we included supplementary questions to gain additional insights from participants. Examples of additional questions include: i) Compared to fully in-person format, how effective were hybrid tutorials in terms of learning? (1 = "least effective"; 5 = "most effective") ii) Please rank your preferences for tutorial session formats (in-person, virtual, or hybrid). For clarification, the surveys provided definitions of the "virtual", "hybrid" and "in-person."

Statistical analysis

The survey data were collected and statistically analyzed using a Microsoft® Excel (Microsoft 365 subscription, Version 16.49 (21050901), Redmond, WA). The mean rating of students' perceptions regarding effectiveness of virtual and hybrid ICCBT, as well as their preferences for ICCBT formats, were calculated and evaluated. One-way analysis of variance (ANOVA) was done to determine if there is a significant difference between the means of the cohorts (Table 1, Table 2) on the two following prompts (core questions).

1. "Compared to in-person format, how effective are virtual tutorials for learning?"
2. "For future case-based tutorials, virtual formats should be considered.

In addition, the distribution of students' responses to core questions was illustrated for the evaluation.

Results

A total of 85 participants, 23 students from the Class of 2023 (V-ICCBT, 71.9 % participation rate), 31 students from the Class of 2024 (C-ICCBT, 91.2 %), and 31 students from

Table 1 Perceived effectiveness of virtual versus in-person format for ICCBT by cohort.

	Mean ± SD	95 % CI	P-value
V-ICCBT (N = 23, conducted in 2021)	4.04 ± 1.31	(3.48, 4.60)	P > 0.45
C-ICCBT (N = 25, conducted in 2022)	4.08 ± 1.05	(3.69, 4.49)	
I-ICCBT (N = 29, conducted in 2023)	3.68 ± 1.17	(3.25, 4.11)	

One-way ANOVA. 1 = "Less effective," 5 = "More Effective".
V-ICCBT: Virtual-Interactive clinical case-based-tutorials, C-ICCBT: Combination-Interactive clinical case-based-tutorials, I-ICCBT: In-person-Interactive clinical case-based-tutorials.

Table 2 Preference for virtual format by cohort.

	Mean ± SD	95 % CI	P-value
V-ICCBT (N = 25, conducted in 2021)	4.04 ± 1.43	(3.46, 4.62)	P > 0.90
C-ICCBT (N = 30, conducted in 2022)	4.10 ± 1.28	(3.64, 4.55)	
I-ICCBT (N = 31, conducted in 2023)	3.94 ± 1.29	(3.48, 4.39)	

One-way ANOVA. 1 = "Strongly disagree"; 5 = "Strongly agree".
V-ICCBT: Virtual-Interactive clinical case-based-tutorials, C-ICCBT: Combination-Interactive clinical case-based-tutorials, I-ICCBT: In-person-Interactive clinical case-based-tutorials.

the Class of 2025 (I-ICCBT, 83.8 %) completed the post-course survey.

Overall, our findings from two core questions revealed non-significance differences in students' perceptions regarding the ICCBT formats across three cohorts.

Question 1: "Compared to in-person format, how effective are virtual tutorials for learning?"

Our study found the means to be 4.0 ± 1.31 (V-ICCBT), 4.08 ± 1.05 (C-ICCBT), and 3.68 ± 1.17 (I-ICCBT) (coefficient 0.79; 95 % CI, $P = 0.456$, $\alpha<0.05$) (Table 1, Fig. 1). One-way ANOVA (Table 1) shows the P value as $P > 0.456$, demonstrating non-significance among the three cohorts as it relates to perceived effectiveness of virtual case-based tutorial sessions. The distribution of students' answers to question 1 can be seen in Fig. 3a and b, which illustrate a more detailed breakdown.

Question 2: "For future case-based tutorials, virtual formats should be considered."

The three cohorts had the following means: 4.04 ± 1.43 (V-ICCBT), 4.10 ± 1.28 (C-ICCBT), and 3.94 ± 1.29 (I-ICCBT) ($P = 0.923$, $\alpha<0.05$, $F_{crit} = 0.08$) (Fig. 2). According to one-way ANOVA (Table 2), the P value as $P > 0.923$ demonstrated insignificance among cohorts as it relates to preference for virtual case-based tutorial sessions. Fig. 4a and b provide a more detailed breakdown of students' responses to question 2.

In our evaluation of supplemental questions regarding the hybrid method within the C-ICCBT cohort, specifically for the ICCBT, we found that the mean preference was 3.57 ± 0.95. Additionally, students from the ICCBT cohort were asked to rank their preferences for tutorial formats: in-person, virtual, and hybrid. Among the thirty-one participants in the C-ICCBT cohort, all students responded to
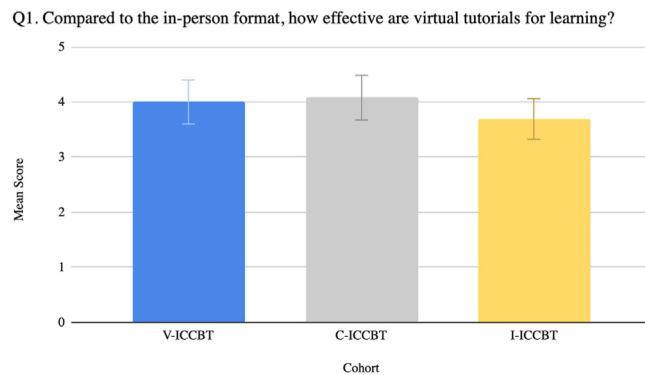

Figure 1 Mean scores of V-ICCBT, C-ICCBT, I-ICCBT for Question 1 (Q1).
Q1 Compared to the in-person, how effective are virtual tutorial for learning? V-ICCBT: Virtual-Interactive clinical case-based-tutorials, C-ICCBT: Combination-Interactive clinical case-based-tutorials, I-ICCBT: In-person-Interactive clinical case-based-tutorials.
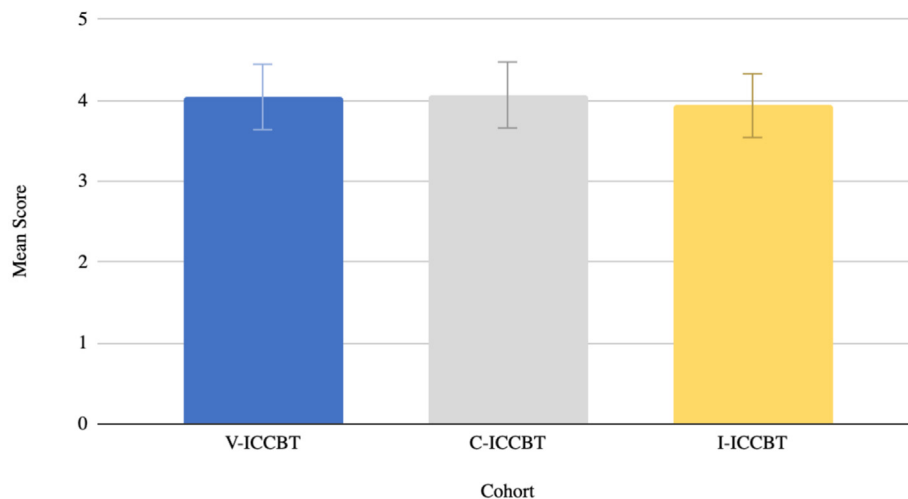

Figure 2 Mean scores of V-ICCBT, C-ICCBT, and I-ICCBT for Question 2 (Q2).
Q2. For future case-based tutorials, virtual formats should be considered. V-ICCBT: Virtual-Interactive clinical case-based-tutorials, C-ICCBT: Combination-Interactive clinical case-based-tutorials, I-ICCBT: In-person-Interactive clinical case-based-tutorials.
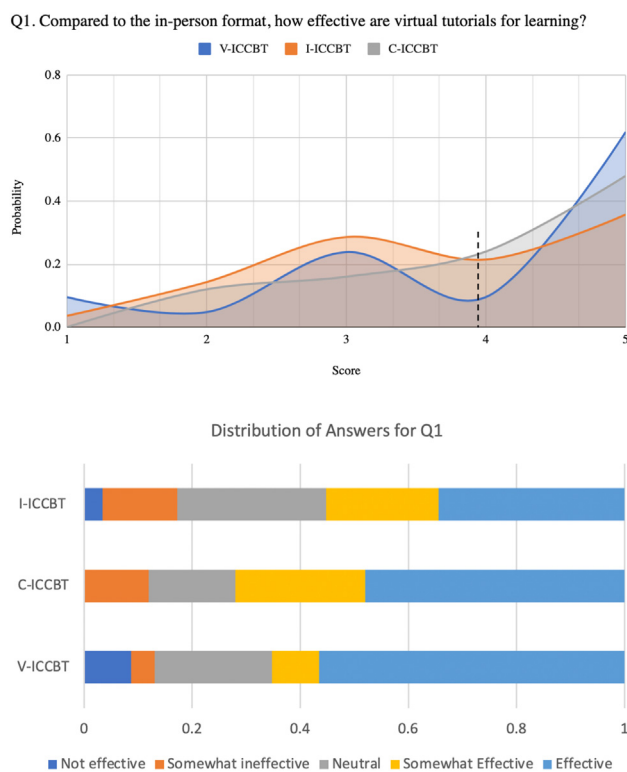
Q1. Compared to the in-person format, how effective are virtual tutorials for learning?

Distribution of Answers for Q1

Figure 3 Distribution of choices for Question 1 between the classes. 3a. Colors represent numbers which correlate to the answer choices explained in methods. 1 = "not effective" to 5 = "effective."
V-ICCBT: Virtual-Interactive clinical case-based-tutorials, C-ICCBT: Combination-Interactive clinical case-based-tutorials, I-ICCBT: In-person-Interactive clinical case-based-tutorials.

the supplemental question to select their first ranked preference. Thirty students specified their second preferred modality, and only twenty-seven specified a third preference. For those who specified their first rank, the majority of students (64.5 %) expressed a preference for the virtual format, with the in-person method as their second choice and hybrid as the least favored. For most students, the hybrid format was their second preference (53.3 %). Only 23.3 % of students prefer the in-person modality as their second choice (Fig. 5).

Furthermore, feedback from students was gathered through open-ended questions, as highlighted in Tables 3a and 3b. Additionally, suggestions based on their experiences are also listed in Table 3c.

Discussion

In recent years, numerous studies have explored the transforming landscape of dental education and the learning experiences of dental students. Particularly, in the wake of the COVID-19 pandemic, there has been a notable focus on investigating the pivotal shift from in-person formats to virtual modalities.

In this study, students from all cohorts— virtual, in-person, a combination of both— expressed a preference for virtual ICCBT sessions, with a slightly lower preference observed within the I-ICCBT cohort. Moreover, all cohorts perceived virtual ICCBT sessions as somewhat more

effective for learning compared to in-person sessions. The P values for the comparison of students' perceptions, with $P > 0.456$ for question 1 and $P > 0.923$ for question 2, suggest that there were no significant differences among the three cohorts, despite variations in their experiences during the ICCBT. This also suggests that the delivery format of ICCBT to each cohort had little impact on their perception and preferences. Conversely, the distributions of students' response to Question 1 and Question 2 revealed that fewer students preferred the virtual format or more students perceived virtual ICCBT as less effective compared to other cohorts. Their exclusive in-person experiences of students in the ICCBT cohort may have influenced their perceptions for this type of learning module.

In this context, these findings also emphasize the need for a comprehensive understanding of the changing dynamics in dental education. Several studies conducted within the realm of online learning in the dental institution setting suggest that active online learning, such as the ICCBT framework, is not only applicable to students but also a viable method of educational delivery.[24,25] When paired with easily accessible and interactive online supplemental materials during remote sessions, students perhaps perceive increased effectiveness, leading to a preference for the virtual tutorial sessions.[26]

It should be noted that the I-ICCBT cohort also prefers and perceives virtual platforms as more effective even without participating in any virtual tutorial sessions. This highlights the importance of understanding the advantages
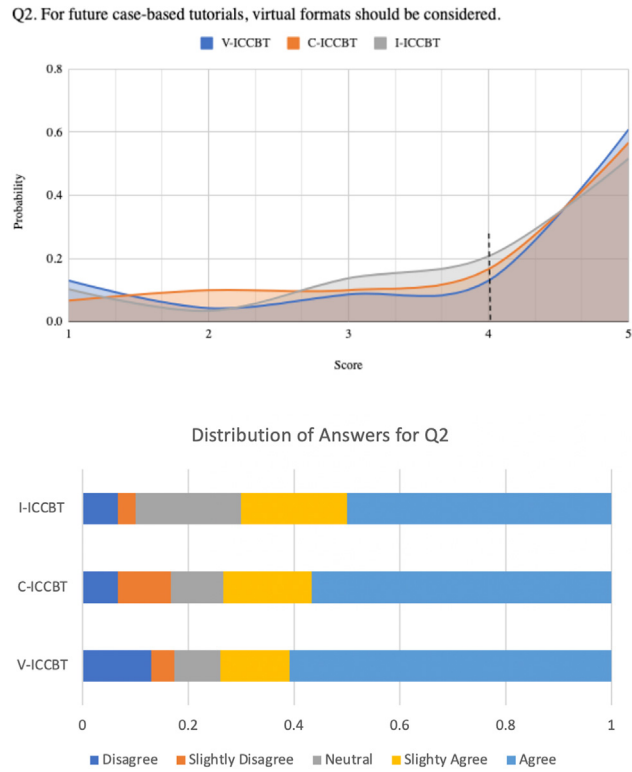
Figure 4 Distribution of choices for Question 2 between the classes. 3a. Colors represent numbers which correlate to the answer choices explained in methods. 1 = "disagree" 5 = "agree."
V-ICCBT: Virtual-Interactive clinical case-based-tutorials, C-ICCBT: Combination-Interactive clinical case-based-tutorials, I-ICCBT: In-person-Interactive clinical case-based-tutorials.

and disadvantages of a virtual platform and identifying potential shortcomings in in-person ICCBT to enhance ICCBL overall. For example, as shown through the student feed-back in Table 3a, virtual ICCBT has the advantages of scheduling flexibility, additional learning features such as the ability to rewatch and pause recorded sessions, and being able to share clinical images, such as radiographs and periodontal charts. In this manner, details might be better
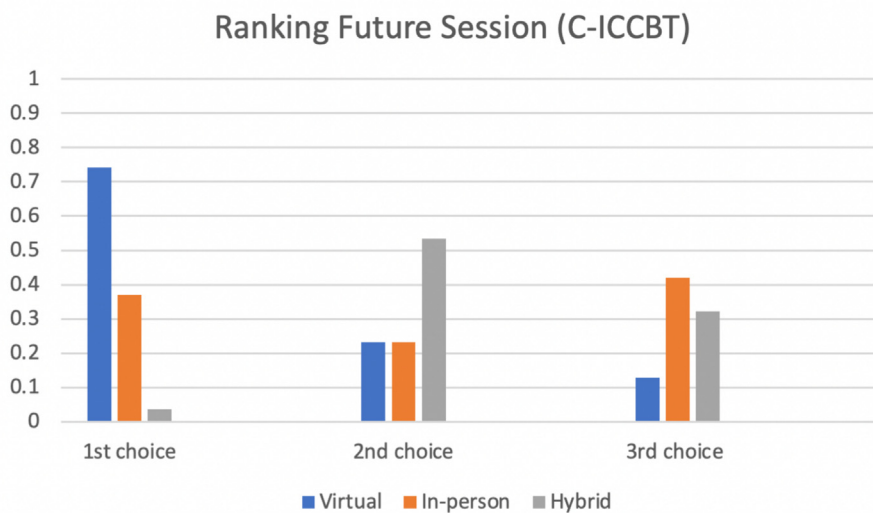

Figure 5 Rankings of 1st, 2nd, and 3rd choices from C-ICCBT. Y-axis fraction of choice over the total number of choices (response rate was not uniform across ranking 1st to 3rd choices)
V-ICCBT: Virtual-Interactive clinical case-based-tutorials, C-ICCBT: Combination-Interactive clinical case-based-tutorials, I-ICCBT: In-person-Interactive clinical case-based-tutorials.

Table 3a   Advantages of virtual ICCBT.

Themes	Representative quotes
Flexibility for scheduling and attendance location	• "Freedom to schedule outside of normal times if need be." (V-ICCBT) • "It's easier to adjust our schedules to have the meeting." (C-ICCBT) • "I had to miss a session because I was sick. Had it been virtual, I would've been able to attend." (C-ICCBT) • "We can learn from the comfort of home." (I-ICCBT)
More learning features	• "Ease of screen sharing and pulling up/presenting external resources." (V-ICCBT) • "Ability to rewatch lectures" (V-ICCBT) • "It's easier to communicate (via chat)." (C-ICCBT) • "You can actually point at images with the cursor, so it's easier to follow along." (C-ICCBT) • "Tutorial leader can record session for students to review." (C-ICCBT)
Supplementation with online resources	• "It was easier to be able to look up supplementary sources to aid in the tutorial points." (V-ICCBT) • "Can share screens and draw digitally to illustrate concepts" (V-ICCBT) • "Can go over cases, x-rays, etc. with screen sharing" (I-ICCBT) • "The share screen function allows instructor or students to supplement learning with online resources" (I-ICCBT)

Table 3b   Challenges of virtual ICCBT.

Themes	Representative quotes
Technical difficulties	• "Internet connections were issues at times." (V-ICCBT) • "technology issues can waste time." (I-ICCBT)
Difficulty of maintaining student engagement	• "I found it more difficult to gauge when to talk and when not to talk. I accidently would start talking at the same time as others." (V-ICCBT) • "It's easier to zone out and not participate." (C-ICCBT)

Table 3c   Student feedback and suggestions.

Cohort	Representative quotes
V-ICCBT	• "Chat with students at beginning of class to get students engaged from the start and get to know you" • "Use virtual functions (poll/yes/no raise hands) with tutor instructions" • "Call on people, it improves participation"
C-ICCBT	• "I think virtual sessions are beneficial. Wish my sessions were virtual." • "Require prior readings and mandatory interactions during sessions" • Increase virtual opportunities"
I-ICCBT	• "I think a combination of both formats is ideal" • "I think the bulk of sessions should be in person with occasional virtual if it is more convenient for scheduling"

V-ICCBT: Virtual-Interactive clinical case-based-tutorials, C-ICCBT: Combination-Interactive clinical case-based-tutorials, I-ICCBT: In-person-Interactive clinical case-based-tutorials.

visualized on a personal screen compared to a single projected image in the classroom.

As seen in the student feedback in Table 3b, one prominent challenge of online learning includes the difficulty of maintaining engagement and retaining learning materials.[23,26] However, the distinctive nature of ICCBT addresses these challenges by encouraging the student to participate in and exploring the multi-faceted solutions to particular cases through group discussion.[27] Our previous study found that students perceived that virtual/distance learning was better suited for didactic content, while it was considered less optimal for clinical subjects.[20] Although the ICCBT is more clinically oriented, it does not directly support learning the technical aspects relating to procedures. Instead, it fosters students' abilities to diagnose, list clinical problems, and create appropriate treatment plans while utilizing critical thinking. Nevertheless, it is crucial to acknowledge that online learning cannot fully replace in-person learning in laboratory, preclinical, and clinical contexts where manual dexterity skills are required.[25] Therefore, online learning should be considered in the context of case-based learning, but further study is needed

to understand how it fits holistically in the puzzle when considering other imperative areas of dental education. Table 3c depicts suggestions made about virtual versus in-person ICCBT sessions, with feedback that implies some combination of formats that strikes a balance between student engagement and session flexibility being ideal.

By employing a combination of qualitative and quantitative methods, this research provided valuable insights into the effectiveness and student preferences for virtual ICCBL, contributing to the ongoing discourse on the future of healthcare education in a technologically driven world. The results indicate a noteworthy shift in perceptions and preferences of students towards virtual education, challenging the conventional emphasis on in-person education in dentistry. Furthermore, it would be worthwhile to explore the integration of AI tools into future virtual ICCBT sessions, given their widespread use and prominence in contemporary dentistry, such as in diagnosis of radiographic caries, classification of cyst and tumor, and enhancement of image quality.[28] Incorporating these AI tools into an interactive, case-based tutorial setting may enhance the quality of discussion, diagnosis and treatment planning, and the retention of educational material.

Although the limitations of this study include surveying a single dental school, our findings could be a valuable addition to optimizing delivery of dental education. Moving forward, surveying a larger number of students in the C-ICCBT cohort may bring clarity to preferences for virtual versus in-person ICCBT sessions, as this group was exposed to both formats. Expanding the sample size and administering the survey across multiple dental schools would enhance the generalizability of the data and further validate the findings of this study.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Acknowledgements

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