ASCILITE 2026

The Future is Connection:

Collaboration, Creativity and Compassion in a Digital Society

Integrating virtual reality and 3D models in orthodontic education: Investigating student engagement with digital diagnostic workflows

Shazia Naser-ud-Din
ZT2B

Michael Cowling
RMIT University

The shift from physical plaster models to digital three-dimensional (3D) representations marks a significant change in orthodontic pedagogy, yet tertiary dental curricula have been slower to adopt digital workflows than clinical practice itself. This paper reports the conceptual framing, literature context, intervention design and methodology of a study investigating final-year Doctor of Dental Surgery (DDS) students' engagement with virtual reality (VR) haptic interfaces and 3D orthodontic models when identifying malocclusions, specifically overjet (OJ) and the Index of Orthodontic Treatment Need (IOTN). A cohort of 43 students took part in a VR-enhanced seminar combining haptic simulation with 3D digital models, building on diagnostic concepts introduced earlier in the program. The study asks how students approach clinical measurement and diagnostic reasoning within an immersive digital environment, and how they envisage translating VR/3D outputs into the laboratory and clinical communication workflows still required of them. A mixed-methods design combines open-ended qualitative survey responses, analysed thematically, with quantitative Likert-scale ratings of task difficulty and teaching satisfaction. The intervention and methodology presented here situate VR-haptic simulation within the broader move toward "digital-native" clinical training that addresses the cost and scalability limits of physical models in large dental cohorts.

Keywords: Virtual reality, orthodontics, dental education, 3D modelling, haptic simulation, mixed methods

Introduction

The landscape of dental education is shifting in response to the wider digitalisation of clinical practice. Traditional orthodontic training has relied heavily on physical plaster models and two-dimensional cephalometric records; these are increasingly being supplemented, and in places replaced, by high-fidelity virtual reality (VR) and haptic simulation systems. Specific dental applications of VR demand an understanding of tactile feedback and spatial depth that general technology-enhanced learning research does not fully address, and dental curricula have been comparatively slow to integrate digital workflows even as digital tools become standard in clinical orthodontic practice.

This study responds to that gap by examining how final-year dental students perceive and use VR-haptic interfaces and 3D digital models to perform core orthodontic diagnostic tasks, specifically the assessment of overjet (OJ) and classification of cases against the Index of Orthodontic Treatment Need (IOTN). These concepts are first introduced earlier in the program and are revisited and extended in the final year, where the digital interface is intended to support authentic, clinic-ready learning for students approaching graduation.

Two research questions guide the study:

RQ1: How do final-year dental students approach clinical measurement and diagnostic reasoning (e.g., OJ assessment, IOTN classification) when using VR-haptic interfaces and 3D digital models?
RQ2: How do students perceive the process of translating immersive 3D diagnostic work into the digital workflows required for laboratory communication and clinical documentation?

Literature review

Orthodontics, and dentistry more broadly, has adopted digital interfaces quickly in clinical applications, but the tertiary education sector has not kept pace with integrating digital formats into curricula. Online orthodontic learning resources built on sound pedagogical, andragogical and heutagogical principles are needed to support the critical thinking, self-directed learning and problem-solving that orthodontic treatment planning demands, and student attitudes are a critical element to consider when designing such resources (Linjawi et al., 2009).

Dentistry and 3D tools

Global dental education has seen a marked increase in the adoption of haptic simulators in recent years (Algarni et al., 2024). Current literature suggests that VR-haptic systems provide a safe, repeatable environment in which students can develop manual dexterity: Li et al. (2021) highlight that the force-feedback in these systems mimics the difference between hard and soft dental tissues. In orthodontics specifically, 3D digital models are now considered the gold standard for treatment planning (Surendran et al., 2024). A recurring theme in this literature is a "transactional distance" between the immersive VR world and the practical clinical requirement of laboratory submission; the present study aims to address this gap by evaluating students' perceived ease of workflow integration.

The evolution of the digital dental paradigm

Digitalisation is no longer a peripheral addition to dental curricula but is increasingly central to developing clinical competency. Modern workflows integrate intraoral scanning, computer-aided design and manufacturing (CAD-CAM), and 3D printing to provide faster, more accurate and patient-oriented solutions. This transformation matters for the current generation of students, who routinely engage with high-fidelity technology in their daily lives and expect institutional training to mirror current technical fluency. The transition from analogue to digital paradigms in dental education represents a profound shift in clinical pedagogy, moving away from static plaster models toward dynamic, interactive and data-driven workflows, and it is this shift that motivates the intervention described below.

Theoretical framework

The emphasis on pedagogical rationale over technological novelty echoes a broader "pedagogy before technology" (PBT) ethos in the technology-enhanced learning literature, which cautions against adopting immersive tools for their own sake and instead foregrounds the learning design problem the technology is meant to solve (Cowling & Birt, 2018). Figure 1 outlines the PBT approach which frames this study, broadly represented as three steps: 1) What is the problem?; 2) How can the problem be solved?; and 3) How can technology help?

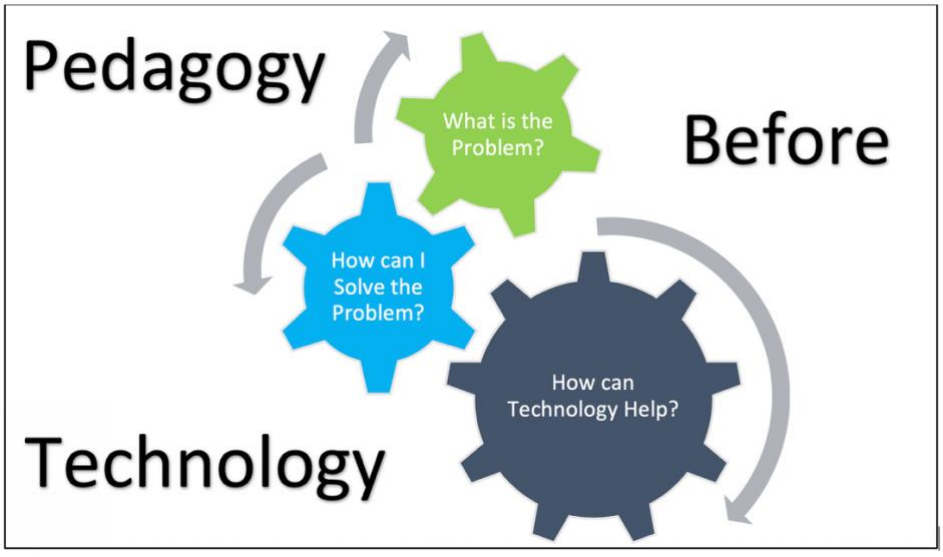


Figure 1. *Pedagogy before technology model* (Cowling & Birt, 2018)

The VR-haptic intervention reported here was deliberately built around the existing OJ and IOTN learning outcomes already embedded in the DDS curriculum, rather than retrofitting the curriculum to the affordances of the platform. This allowed us to address steps one and two of the PBT model directly, and move straight to step three, looking at how technology could help. In addressing this step, we then also incorporated existing learning with regards to 3D tools in the literature to consider the use of extended reality, which resulted in our intervention design, detailed below.

The intervention

The intervention was delivered as a structured seminar for final-year DDS students, combining a proprietary VR-haptic dental platform with 3D digital orthodontic models. The seminar opened with a guided demonstration of the platform on a large screen, introducing students to its object-interaction controls before they moved to hands-on use (Figure 2, left photo). Students then worked individually with a VR headset, using hand-tracked gestures to manipulate and inspect 3D dental arches in an immersive environment (Figure 2, right photo). This hands-on phase was supported by facilitators who guided students through the interaction model and answered questions about the platform in real time.



Figure 2. *Facilitator introducing the VR-haptic platform's object-interaction controls on a 3D dental arch model at the start of the seminar, along with the VR demo for individual students.*

Following the immersive component, students applied the same diagnostic concepts to annotated 3D digital models presented on screen, working through sample cases that recorded IOTN level and a structured problem list (e.g., open bite, OJ, crowding, midline discrepancy) for each model (Figure 3). This stage was designed to bridge the immersive VR experience with the static digital outputs students are required to produce for laboratory communication and clinical documentation, which is the transition examined in RQ2, and used augmented reality (AR) (Cowling et al., 2016).

Informal feedback gathered from students during and immediately after the seminar reinforced this picture. Several students commented that the headset and gesture controls felt intuitive once explained, but said they fell back on familiar habits when measuring OJ: describing it in terms of crown height or simply "eyeballing" the distance and would benefit from the platform having built-in measurement tools. Students also flagged practical friction points, including at least one device that could not run the platform because of an outdated software version, and asked for clearer guidance on how a finished 3D diagnosis should be packaged and sent to the laboratory, with several suggesting simple conventions such as colour-coded annotations or an accompanying screenshot. This informal feedback is what is now being formalised and analysed through the thematic and quantitative methodology described below, and will directly shape the refined prototype taken into the next DBR cycle.

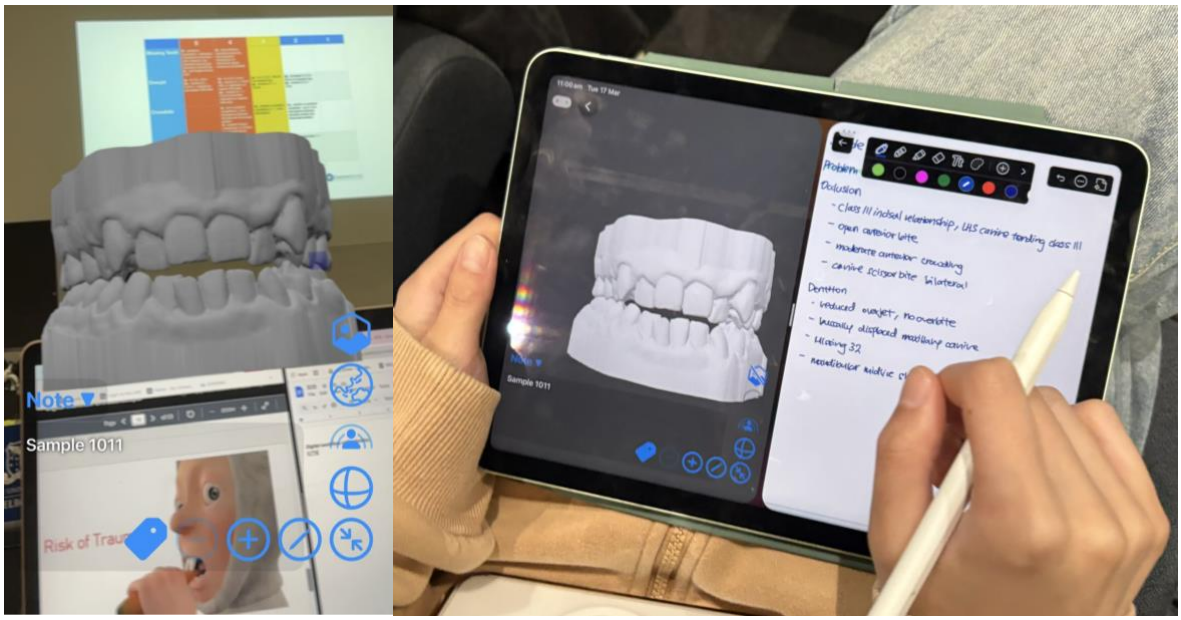


Figure 3. *An annotated 3D digital model with IOTN level and structured problem list, used during the seminar's diagnostic walkthrough, shown on both iPad and an iPhone with camera passthrough (AR).*

Methodology

Given this informal feedback on the app provided by students, we now propose a structured study that will look to answer our research questions. This study will follow a design-based research (DBR) approach, in which the VR-haptic intervention is iteratively analysed, designed, implemented and evaluated in collaboration with the students and teaching team who use it, with each cycle's findings feeding directly into the refinement of the next prototype (Koh et al., 2024; Reeves, 2006). The seminar and cohort reported in this concise paper represent the first part of this cycle, before formal data collection begins. Following this, we will conduct further interventions with dentistry students as part of our study, using a mixed-methods design, with data collection comprising a multi-part survey combining open-ended qualitative questions and quantitative Likert-scale ratings, administered immediately after the seminar. Ethics approval will be sought prior to conducting this formal data collection.

The survey that we administer to students will address four domains:

1. clinical assessment techniques, that is, methods used for measuring OJ;
2. diagnostic competency, that is, identifying IOTN level and dental trauma risk;
3. technological workflow, that is, proposed methods for communicating 3D data with dental laboratories;
4. and pedagogical feedback, that is, quantitative ratings of task difficulty and teaching satisfaction.

Qualitative responses will then be coded using thematic analysis (Braun & Clarke, 2006) to identify recurring patterns in students' clinical reasoning, addressing RQ1 and RQ2. Quantitative confidence and difficulty scores will be analysed descriptively alongside the qualitative themes to characterise students' overall experience of the VR-haptic seminar. As a concise paper, this report focuses on the problem, research questions, literature context, intervention design and methodology of the study; the quantitative and thematic findings will then be reported in a full manuscript at a later date.

Conclusion

This concise paper has set out the problem, research questions, literature context, intervention design and methodology for a study of VR-haptic and 3D digital model use in final-year orthodontic education. What is reported here is the first tranche of the intervention: an initial seminar build of the VR-haptic platform and 3D

diagnostic walkthrough, put in front of a cohort of dentistry students to gather their feedback on the platform, the seminar structure and the diagnostic tasks themselves. That feedback now informs a refined prototype, to which the DBR methodology outlined above will be applied across subsequent cycles of implementation and evaluation with future cohorts.

Closing the gap between immersive 3D diagnostic reasoning and the 2D outputs still required for laboratory and clinical communication would do more than improve one seminar: it would offer a genuinely scalable, digital-native alternative to plaster-model teaching at the point where large cohort sizes currently make authentic, hands-on diagnostic practice logistically and financially difficult. Realising that outcome, and not merely demonstrating the platform, is the task of the next stage of this research.

References

Algarni, Y. A., Saini, R. S., Vaddamanu, S. K., Quadri, S. A., Gurumurthy, V., Vyas, R., Baba, S. M., Avetisyan, A., Mosaddad, S. A. & Heboyan, A. (2024). The impact of virtual reality simulation on dental education: A systematic review of learning outcomes and student engagement. *Journal of Dental Education, 88*(12), 1549–1562. https://doi.org/10.1002/jdd.13619

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Cowling, M., & Birt, J. (2018). Pedagogy before technology: A design-based research approach to enhancing skills development in paramedic science using mixed reality. *Information, 9*(2), 29. https://doi.org/10.3390/info9020029

Cowling, M., Tanenbaum, T. J., Birt, J., & Tanenbaum, K. (2016). Augmenting reality for augmented reality. *Interactions*, *24*(1), 42-45.

Koh, J., Cowling, M. A., Jha, M., & Sim, K. N. (2024). Design-based research as a value-added methodology for artificial intelligence in education. In K. Barua, N. Radwan Mohammed, V. Singh, & R. Figueiredo (Eds.), *Design and implementation of higher education learners' learning outcomes (HELLO)* (pp. 349–367). IGI Global. https://doi.org/10.4018/978-1-6684-9472-1.ch022

Li, Y., Ye, H., Ye, F., Liu, Y., Lv, L., Zhang, P., & Zhou, Y. (2021). The current situation and future prospects of simulators in dental education. *Journal of Medical Internet Research, 23*(4), e23635. https://doi.org/10.2196/23635

Linjawi, A. L., Hamdan, A. M., Perryer, D. G., Walmsley, A. D., & Hill, K. B. (2009). Students' attitudes towards an on-line orthodontic learning resource. *European Journal of Dental Education, 13*(2), 87–92. https://doi.org/10.1111/j.1600-0579.2008.00545.x

Reeves, T. C. (2006). Design research from a technology perspective. In J. van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational design research* (pp. 52–66). Routledge.

Surendran, A., Daigavane, P., Shrivastav, S., Kamble, R., Sanchla, A. D., Bharti, L., & Shinde, M. (2024). The future of orthodontics: Deep learning technologies. *Cureus*. https://doi.org/10.7759/cureus.62045

Naser-ud-Din, S. & Cowling, M. (2026). Integrating virtual reality and 3D models in orthodontic education: Investigating student engagement with digital diagnostic workflows. In Cochrane, T., Narayan, V., Poole, T., Lai, P., Lake, P., Moore, O., & Li, L. (Eds.), *The Future is Connection: Collaboration, Creativity and Compassion in a Digital Society*. Proceedings ASCILITE 2026. Brisbane (pp. 747–751). https://doi.org/10.65106/apubs.2026.3382

Note: All published papers are refereed, having undergone a double-blind peer-review process.
The author(s) assign a Creative Commons by attribution license enabling others to distribute, remix, tweak, and build upon their work, even commercially, as long as credit is given to the author(s) for the original creation.

© Naser-ud-Din, S. & Cowling, M. 2026