Challenges and Pathways for the Professional Development of Dental Technology Educators

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Abstract: Dental technology is a highly specialized and practice-oriented discipline, in which the professional development of its educators directly impacts the quality of talent cultivation. In recent years, driven by the rapid iteration of digital dental technology and the in-depth advancement of the "New Medical Sciences" initiative, dental technology educators face multiple pressures, including technological updates, pedagogical transformation, and the integration of industry and education. Based on an analysis of the role orientation and core competencies of dental technology educators, this study outlines the main challenges faced by this group in their professional development. These challenges include the pressure of technological iteration and knowledge updates, difficulties in pedagogical transformation, insufficient depth in industry-education integration, and an inadequate support system. Dental technology educators should continuously enhance their comprehensive qualities through concept renewal, skill development, technology empowerment, industry-education collaboration, integration of research and teaching, and teaching reflection. Actively exploring practical pathways to promote the professional development of dental technology educators will drive the high-quality development of dental technology education.

***Keywords*:** dental technology, teacher professional development, artificial intelligence, teaching competence, integration of industry and education

1. Introduction

Dental technology is an interdisciplinary field bridging medicine and engineering, primarily cultivating specialized talents engaged in dental prosthesis fabrication, digital dental design, and dental material applications. The distinctiveness of this specialty lies in its requirement for both medical precision and engineering meticulousness; it demands understanding clinical needs while mastering technical craftsmanship. Educators responsible for imparting this knowledge and skills naturally assume a unique mission.

In recent years, the pace of advancement in dental technology has been remarkable. Digital scanning, CAD/CAM restorations, 3D printing, dental implant navigation... technologies that were still conceptual a decade ago have become industry standards [1]. This rapid technological iteration directly impacts the educational sector – whether graduates can keep pace with industry developments largely depends on whether educators possess the foresight and expertise. Research indicates that the application of digital technology in dental education has permeated five main areas, including online teaching, virtual simulation, and digital assessment systems [2]. Concurrently, national-level initiatives are driving medical education reform. The introduction of the "New Medical Sciences" concept in 2018 emphasized interdisciplinary integration and intelligent empowerment; the launch of the "Artificial Intelligence + Higher Education" initiative in 2024 further propelled the integration of technology into teaching. These policy directions present new requirements for all medical educators, and dental technology educators are naturally no exception.

I also observe a practical issue: current research on teacher professional development predominantly targets clinical medicine faculty or dental medicine educators, with very few studies specifically focusing on the "dental technology educator" group. Dental technology educators are quite unique – they are neither purely clinical practitioners nor typical engineering instructors, but rather "dual-qualified" talents situated between medicine and technology. Research shows that dental technology education requires designing a curriculum system conducive to teamwork among oral health professions [3]. Their professional development pathways cannot simply replicate models from other groups. Therefore, this article, combining literature analysis and observations from teaching practice, systematically outlines the challenges faced by dental technology educators and explores suitable pathways for their professional development.

2. Role Orientation and Core Competencies of Dental Technology Educators

To discuss professional development, one must first clarify the role of this group. The dental technology specialty cultivates

talents in dental prosthetics, digital dental design, and denture processing. Educators in this field must understand foundational theories of dental medicine, master various technical crafts, and integrate both aspects effectively in their teaching.

Research suggests that information technology holds immense potential in dental education, and dental educators need to help students develop competencies and promote professional growth [4]. This perspective applies equally, if not more, to dental technology educators. Based on practical observations, the current roles of dental technology educators include at least the following:

① Transmitter and Applicator of Techniques: This is fundamental. Students must learn to fabricate prostheses and perform designs; educators themselves must first understand and master these skills. However, with accelerating technological updates, the standard of "mastery" constantly evolves. Proficiency in metal-ceramic crowns was once sufficient; now CAD design and 3D printer operation are necessary. Research indicates that dental technology educators need to integrate skills, knowledge, and curriculum reform to adapt to industry changes [5].

② Guide for Digital Teaching: Many institutions have introduced virtual simulation systems and dental design software. How to use these tools, in which teaching phases, and how to maximize student benefit requires educator guidance. Studies show that teacher professional development in dental education is closely linked to emerging pedagogies and necessitates instructional innovation [6].

③ Designer of Personalized Practice: Students possess varying skill levels; some excel in hands-on abilities, others in theoretical foundations. Designing differentiated training content within limited instructional hours requires educators to act as designers, tailoring activities to individual student needs.

④ Promoter of Industry-Education Integration: This specialty is closely tied to industry. Educators must understand whether the taught content aligns with corporate needs and whether graduates can perform effectively upon employment. Collaboration between industry and vocational education can enhance educational quality and relevance [7].

⑤ Conveyor of Craftsmanship Spirit: Dental prosthetics requires high precision; even minor errors can lead to significant issues. While techniques can be taught, attitudes of continuous improvement and responsibility towards patients are often instilled gradually by educators through daily instruction. Research highlights that vocational education standards need to support the professional development of all dental educators [8].

The convergence of these roles imposes significant demands on educators. However, in reality, few educators excel in all these roles. What are the underlying issues? This leads to the subsequent discussion.

3. Main Challenges in the Professional Development of Dental Technology Educators

Through years of interaction and observation of numerous dental technology educators, the pressure faced by this group is greater than many imagine. The main challenges are reflected in the following six aspects:

3.1 Rapid Technological Updates and High Pressure from Knowledge Iteration

A seasoned educator with over a decade of experience in denture processing remarked: "Previously, a set of techniques could last ten years; now, failing to learn new things for three years renders one outdated." This sentiment is accurate. The iteration cycle of digital dental technology is shortening, with CAD/CAM software upgrading every year or two, and new materials and processes emerging continuously [9]. Educators often have heavy teaching loads, leaving insufficient time for systematic learning of new technologies. In recent years, digital dental education has been undergoing profound transformation, requiring ongoing educational innovation and teacher training [10].

3.2 Difficulty Transforming Teaching Methods to Suit the Learning Characteristics of a New Generation of Students

Today's students are digital natives, accustomed to fragmented, visual, and interactive learning styles. However, many educators still employ traditional "teacher lectures, student listens" methods. Furthermore, continuing professional development (CPD) has a positive impact on the learning, behavior, or patient outcomes of dental professionals [11]. This is not to say lecturing is ineffective; the problem is that for skill-intensive courses like dental prosthetics, students cannot truly learn solely through listening and observing. A more complex issue arises with the introduction of new tools like virtual simulation systems and digital design software – many educators have not yet fully mastered these themselves, let alone used them for innovative teaching. Research indicates that 3D digital technology can serve as an alternative teaching tool in preclinical dental education [12].

3.3 Insufficient Depth in Industry-Education Integration and Educator Disconnect from Industry

Dental technology is a quintessential applied discipline; teaching content must align closely with clinical demands

and industry developments. Yet, many educators remain primarily within academic settings for extended periods, with few opportunities to engage directly with industry. Relevant studies suggest that collaboration between universities and dental clinics can offer new possibilities for dental education [13]. Opportunities for collaboration between the corporate sector and the dental education community are worth exploring [14].

3.4 Disconnect Between Research and Teaching, Hindering Reciprocal Enhancement

Younger faculty face pressure to publish papers and secure grants, which requires significant time. The challenge is that much research conducted bears little relation to teaching. Studies indicate that new scientific concepts influencing dental education include interdisciplinary approaches and translational research [15]. The critical question of whether faculty development enhances teaching effectiveness warrants deep consideration in the dental education field [16].

3.5 Tendency to Neglect Ethics and Humanities Education

Given the highly "technical" nature of this specialty, both educators and students may fall into the misconception that technical proficiency alone suffices. However, dental prosthetics involves patient health, aesthetics, and psychological well-being, extending beyond mere technical parameters. Research shows that studies on student perceptions of digital dental technology indicate positive views but underscore the need for enhanced digital literacy training [17].

3.6 Inadequate Institutional Support Systems and Misguided Evaluation Criteria

The existing faculty evaluation system is not particularly favorable for dental technology educators. Promotions often depend on publications and grants, whereas many technical educators excel in practical teaching and skills instruction, which receive less weight in evaluations. Most institutional training is generic, with few specialized programs tailored to the needs of technical educators. Research emphasizes that collaboration between vocational education and training institutions and industry sectors is crucial for improving vocational education quality and relevance [18].

4. Practical Pathways to Promote the Professional Development of Dental Technology Educators

Considering the challenges analyzed above, the author suggests exploring the professional development of dental technology educators through the following avenues:

4.1 Renew Educational Concepts and Achieve Role Transformation

Many educators believe teaching involves simply passing on what they know. However, in today's context of rapid technological change, this approach is no longer sufficient. Students can access vast knowledge online; an educator's strength lies not in possessing more information but in guiding students to learn, to learn how to learn, and to cultivate a love for learning. This necessitates a shift in role perception – from being a knowledge monopolist to becoming a guide and companion on students' learning journeys. In the specific field of dental technology, this means shifting from "teaching techniques" to "teaching thinking, methods, and standards." For instance, when teaching CAD design, the focus should not be on memorizing software menus but on imparting design logic, aesthetic principles, and clinical considerations. Research indicates that digital technology is transforming oral health diagnosis and treatment planning [19].

4.2 Implement Tiered and Categorized Capacity-Building Training

Educators with different backgrounds and at different career stages require different forms of support. Institutions should design differentiated development programs: For digital competencies, specialized training can be offered, such as inviting industry engineers to explain the latest CAD/CAM software operations or organizing workshops on applying virtual simulation teaching systems. Research demonstrates the value of modular digital and 3D-printed dental models in dental education [20]. For teaching competencies, experiences can be drawn from domestic and international sources. How to design case-based teaching, organize problem-based learning (PBL), implement flipped classrooms – while these pedagogical methods may seem conventional, their application within dental technology curricula warrants in-depth exploration. Studies show that acquiring and developing teaching skills for dental educators requires systematic training [21]. For "dual-qualification" competencies, the crucial aspect is creating pathways for industry engagement. Institutions should establish stable collaborations with denture processing centers and dental medical device companies, enabling regular practical experience for educators. Work shadowing has shown positive effects in dental teaching practice [22].

4.3 Promote Technology Empowerment and Enhance Digital Teaching Capabilities

Many institutions have acquired virtual simulation systems, but utilization rates remain low. The issues often lie in

educator unfamiliarity and poor integration between equipment and curriculum. For technology to be effective, educators must first use it and become comfortable with it. Research highlights the significant value of CAD/CAM and digital workflow training in dental vocational education [23]. Institutions can organize small trial teams, allowing core faculty to learn and use new technologies first, subsequently encouraging others. Educators can be encouraged to develop supplementary digital teaching resources for their courses, such as virtual case libraries, 3D model libraries, and instructional videos. Research indicates positive student perceptions of fully digital workflows using 3D printing [24].

4.4 Deepen Industry-Education Collaboration and Leverage Industry Resources for Educator Development

While industry-education integration has been discussed for years, profound implementation remains limited. The author suggests focusing on several aspects: First, jointly establish training bases. Institutions and enterprises can co-build "dual-qualified" teacher training bases, allowing educators to practice in enterprises and industry engineers to teach at the institution. Furthermore, collaboration between industry and educational institutions benefits both parties [25]. Second, engage in project collaboration. Institutions and enterprises can cooperate on technical projects, such as applied research on new materials or digital workflow optimization. Educators participating with students can build capacity while serving industry. Third, co-develop teaching resources. Enterprises possess real clinical cases and cutting-edge processes, while institutions have theoretical expertise and talent. Both can collaborate on developing teaching cases, compiling textbooks, and producing instructional videos. Research shows industry influence on dental education spans training, certification standards, and more [26].

4.5 Foster Integration of Research and Teaching, Enabling Research to Inform Teaching

This does not discourage educators from basic research but encourages transforming research outcomes into teaching resources. For example, research on new restorative materials can be integrated into relevant courses to expose students to cutting-edge developments. Research on digital design methods can be developed into teaching modules, allowing students to engage with the latest technologies. Institutions can also guide this through project design, such as establishing teaching reform research grants supporting studies on curriculum development, teaching methods, and industry-education integration.

4.6 Improve Institutional Safeguards and Optimize Evaluation and Incentive Systems

Teachers' professional development cannot rely solely on individual initiative; institutional safeguards are necessary: Evaluation mechanisms need adjustment. For dental technology educators, evaluation should extend beyond publications and grants. Teaching effectiveness, skill levels, social service contributions, and industry-education integration outcomes should all be included in assessment. Training systems require improvement. Develop tiered and categorized training programs tailored to the characteristics of technical educators. Training formats can be flexible, combining online and offline approaches, internal and external resources. Mentorship systems should be implemented. Upon entry, new faculty can be paired with experienced mentors for guidance in teaching, research, and practice. Mentorship must be substantive, not merely symbolic. Faculty development for clinical teachers is crucial in dental education [27]. A supportive culture should be cultivated. Encouraging innovation, tolerating failure, and supporting collaboration are vital for teacher growth. Institutions can facilitate teacher exchange and mutual learning through teaching salons, workshops, and experience-sharing sessions.

5. Conclusion

Reflecting on the words of an experienced educator: "Teaching dental technology is not just teaching a craft, but also teaching responsibility." This captures the unique nature of this specialty and the significance of its educators. The professional development of dental technology educators indeed faces numerous difficulties: rapid technological change, needed pedagogical transformation, close industry linkages, integrating research and teaching, upholding ethical education, and ensuring institutional support – none of these challenges are easily resolved.

Yet precisely because it is difficult, it demands our reflection, exploration, and practice. The pathways proposed in this article constitute only a preliminary framework. Their specific implementation requires further empirical research. For instance, what are the differences in challenges faced by educators across regions and institution types? Which training measures are most effective? What are the optimal models for university-industry collaboration? These questions warrant further in-depth investigation.

Nevertheless, one point remains clear: Stronger educators lead to stronger programs; stronger programs produce stronger students. It is hoped that more attention will be directed towards this group, collectively promoting the high-quality development of dental technology education.

References

[1] Khurshid Z. Digital dentistry: transformation of oral health and dental education with technology[J]. European Journal of Dentistry, 2023, 17(4): 943-954.
[2] Zitzmann NU, Matthisson L, Ohla H, et al. Digital undergraduate education in dentistry: a systematic review[J]. International Journal of Environmental Research and Public Health, 2020, 17(9): 3269.
[3] Evans J, Henderson A, Johnson N. The future of education and training in dental technology: designing a dental curriculum that facilitates teamwork across the oral health professions[J]. British Dental Journal, 2010, 208(5): 227-230.
[4] Mattheos N, Stefanovic N, Apps A. Potential of information technology in dental education[J]. European Journal of Dental Education, 2008, 12(s1): 85-92.
[5] Bobich AM, Mitchell BL. Transforming dental technology education: skills, knowledge, and curricular reform[J]. Journal of Dental Education, 2017, 81(9): eS46-eS54.
[6] Zheng M, Bender D. Faculty professional development in emergent pedagogies for instructional innovation in dental education[J]. European Journal of Dental Education, 2017, 21(4): 201-210.
[7] Omar M, Kamaruzaman FM. Technical and Vocational Education Training and Industry Collaboration: A Bibliometric Review[J]. Journal of Education and Learning, 2024, 18(1): 1-15.
[8] Field J, Spencer R, Johnson I, et al. Professional standards in dental education[J]. British Dental Journal, 2020, 228(7): 524-528.
[9] Saeidi AA, Fareed WM, Alshahrani A. Digital Technologies in Dentistry: A Study on CAD/CAM, 3D Printing, Digital Impressions and Digital X-Ray among Dental Professionals[J]. South East European Journal, 2024, 18(2): 100-112.
[10] Ardila CM, González-Arroyave D. Efficacy of CAD/CAM technology in dental procedures performed by students: a systematic scoping review of randomized clinical trials[J]. Heliyon, 2023, 9(3): e14129.
[11] Firmstone VR, Elley KM, Skrybant MT. Systematic review of the effectiveness of continuing dental professional development on learning, behavior, or patient outcomes[J]. Journal of Dental Education, 2013, 77(3): 300-315.
[12] Yamakami SA, Nagai M, Chutinant S. 3D Digital technology as an alternative educational tool in preclinical dentistry[J]. European Journal of Dental Education, 2022, 26(2): 329-338.
[13] Heitkamp SJ, Röttermann S, Gerhardt-Szép S. Work shadowing in dental teaching practices: evaluation results of a collaborative study between university and general dental practices[J]. BMC Medical Education, 2018, 18(1): 50.
[14] Alexander D, Clarkson J, Buchanan R. Exploring opportunities for collaboration between the corporate sector and the dental education community[J]. European Journal of Dental Education, 2008, 12(s1): 4-11.
[15] Iacopino AM. The influence of "new science" on dental education: current concepts, trends, and models for the future[J]. Journal of Dental Education, 2007, 71(4): 450-462.
[16] Hendricson WD, Anderson E. Does faculty development enhance teaching effectiveness?[J]. Journal of Dental Education, 2007, 71(12): 1513-1533.
[17] Wang X, Wan Z, Feng X, et al. Perceptions of a digital dental technology curriculum: a qualitative study of dental technology students[J]. European Journal of Dental Education, 2025, 29(1): 130-142.
[18] Omar M, Kamaruzaman FM. Technical and Vocational Education Training and Industry Collaboration: A Bibliometric Review[J]. Journal of Education and Learning, 2024, 18(1): 1-15.
[19] Khurshid Z. Digital dentistry: transformation of oral health and dental education with technology[J]. European Journal of Dentistry, 2023, 17(4): 943-954.
[20] Petre AE, Pantea M, Drafta S, et al. Modular digital and 3D-printed dental models with applicability in dental education[J]. Medicina, 2023, 59(1): 116.
[21] Lyon LJ, Hoover TE, Giusti L, et al. Teaching skill acquisition and development in dental education[J]. Journal of Dental Education, 2016, 80(8): 916-925.
[22] Heitkamp SJ, Röttermann S, Gerhardt-Szép S. Work shadowing in dental teaching practices: evaluation results of a collaborative study between university and general dental practices[J]. BMC Medical Education, 2018, 18(1): 50.
[23] Carrasco-Guardiola I. CAD/CAM and Digital Flow Training in Dental Hygiene Vocational Education[J]. PMC, 2025.
[24] Kraemer-Fernandez P, Spintzyk E, Wahl E, et al. Implementation of a full digital workflow by 3D printing intraoral splints used in dental education[J]. Dentistry Journal, 2022, 11(1): 5.
[25] Evans J, Henderson AJ, Sun J, et al. The value of inter-professional education: a comparative study of dental technology students' perceptions across four countries[J]. British Dental Journal, 2015, 218(5): 295-300.
[26] Gillis MR, McNally ME. The influence of industry on dental education[J]. Journal of Dental Education, 2010, 74(10): 1081-1089.
[27] Møystad A, Lycke KH, Barkvoll T. Faculty development for clinical teachers in dental education[J]. European Journal of Dental Education, 2015, 19(4): 205-210.