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Original Article

Integrating digital technologies in dental technician education: A comparative study of national examination in Asian countries

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KEYWORDS
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Abstract *Background/purpose:* The integration of digital technologies in dental technician education revolutionized the profession in Asian countries. Despite the growing adoption of digital methods, national examinations predominantly relied on traditional techniques. This study aimed to conduct a comparative analysis of national examination standards and digital course integration in dental technician education among 5 countries including Japan, Taiwan, South Korea, the Philippines, and China.
Materials and methods: Data were collected from government agencies, universities, academic organizations, professional associations, and relevant certifying institutions. The study examined the educational methodologies and regulatory frameworks in these countries, focusing on incorporating digital technologies in training and assessment.
Results: The findings revealed significant variations in the integration of digital technologies. Japan and South Korea made substantial progress in embedding digital education in their curricula, while the Philippines and China remained in the early stages. Taiwan showed a balanced approach with a mixture of digital and traditional methods. Practical examinations in most countries remained rooted in conventional techniques, highlighting a gap between educational advancements and examination practices.
Conclusion: To better prepare students for the evolving demands of the dental technology industry, it was crucial to adopt a balanced approach that combined digital learning with hands-on training. This study advocated for educational reforms that bridged the gap between

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traditional training methods and modern digital practices. Enhanced international cooperation and the continuous updating of training programs were essential for advancing the quality of dental technician education, which in turn improved overall oral health outcomes.

Introduction

Behind a beautiful smile, there must be a great dentist; behind the dentist, there must be an experienced dental technician.[1] Dentures are crafted by dental technicians,[2] a job that requires considerable precision. Dental technicians play a crucial role in dental clinics alongside dentists, dental hygienists, and dental assistants. The activity of the dental technician as a member of the dental team, restoring the defects of the dental rows, aims to produce services through dental prosthetic structures, orthodontic appliances, and splints made by him.[3,4] Following the dentist's instructions, the dental technician performs independently responsible tasks related to the planning and manufacturing of dental prosthetic structures, orthodontic appliances, splints, and other dental practice activities.[5,6] To achieve quality in the production of each dental prosthetic structure, the dental technician applies qualified knowledge and experience to find an optimal medical and technical solution for each individual case, for which he bears personal responsibility.[7] As digital technology continues to advance, the application of educational technology in medical technology education is becoming increasingly widespread, and dental technician education is no exception. Educational technology helps improve the quality of education and learning outcomes and effectively addresses many challenges inherent in traditional educational models.

Dental technology is a profession that requires a high level of expertise.[4] In different countries, there are specific regulations governing dental technicians. Dental technicians refer to individuals recognized by their respective governments as practicing dental technical work and obtaining certification through examinations. After graduating from school, learning some standard dental technology procedures takes about four months, but it typically takes five years to become an excellent dental technician.[8] Talent education in schools is a fundamental matter. According to research by Smith[9] and Koolivand,[10] the application of educational technology in dental technician training has significantly enhanced learning outcomes and skill acquisition. Simulation training and digital assessment tools have effectively improved students' practical abilities and examination pass rates. The emphasis is on the application of educational technology in examinations and training processes. During school, through digital operation technology courses, students can learn by integrating hands-on practice with digital techniques, thereby deepening their understanding and mastery of professional skills. The ratio of practical courses to theoretical courses is nearly equal. Developing operational skills is more challenging than acquiring professional knowledge, which requires extensive hours of sculpting practice, sensitivity to color, attention to subtle differences, and consistent concentration in training a dental technician. Therefore, these courses were teaching methods crucial particularly. Students may struggle to focus on their studies without engaging in teaching techniques, leading to a gradual decline in industry talent.

Dental technician education faces significant challenges, including rapid technological advancements, insufficient funding, and reforming curricula to meet industry expectations.[11] However, there is currently almost no discussion worldwide regarding the examinations or learning experiences of dental technicians, and relevant literature is also quite scarce. This study aimed to explore schools of dental technology in the Asian region, focusing on the differences and comparisons in digital courses and national license examinations for dental technology.

Materials and methods

This study defined dental technicians from Japan, Taiwan, South Korea, the Philippines, and China as individuals engaged in dental technical work. For readability, both 'dental technicians' and 'dental technologists' are referred to as 'dental technicians' throughout the study. The data collection process involved several key sources: government agencies, universities, academic organizations, professional associations, national licensing bodies, and relevant certifying institutions (Table 1). Additionally, data was gathered from related research papers and academic journals.

Data collection

Taiwan

Comprehensive data was primarily sourced from the Ministry of Examination and the Health Personnel Licensing Examination Institute. These agencies provided detailed information on dental technicians' qualifications, certification processes, and continuing education requirements.

South Korea

Data was collected from the Korean Dental Technologists Association and the Health Personnel Licensing Examination Institute. The data included details on professional certification, licensing requirements, and educational standards.

Table 1 Reference URL list by country.

Country	Qualification/URL
Taiwan	www.moex.gov.tw web.szmc.edu.tw/Study/D/?page = home www.smc.edu.tw/nss/p/68002
Japan	www.nichigi.or.jp www.nichigi.or.jp/about_shikagikoshi/gakkouitiran.html medical.kawahara.ac.jp/academics/dental_eng/
South Korea	www.kuksiwon.or.kr/main/indexNew.do?seq = 2 www.hit.ac.kr/Chinese/major_medical1_chigi
Philippines	www.prc.gov.ph www.tesda.gov.ph/Tvi/Result?SearchCourse = dental + laboratory tesdaonlineprogram.com/tesda-dental-technology-nc-iv-course/
China	www.21wecan.com reurl.cc/MOoMeL

Japan

The Japanese Dental Technologists Association, a non-governmental organization, was the main source of data. Although this provided thorough information, accessing and interpreting the data posed challenges due to language barriers and specific regional regulations.

Philippines

Information was retrieved from the Professional Regulation Commission and the Technical Education and Skills Development Authority. The data collection involved multiple rounds of searching and comparison to ensure accuracy and completeness.

China

Data availability was limited due to the nature of public information accessibility in the People's Republic of China. Relevant data was found through the Health Human Resources Development Center and the Ministry of Education. For more comprehensive information, consultations with civil organizations and non-profit groups were required.

Data verification and analysis

All collected data underwent a rigorous verification process to ensure accuracy and reliability. The verification involved cross-checking information from multiple sources and validating data against official records and research publications.

The analysis of the data comprised both quantitative and qualitative methods. Quantitative analysis involves statistical techniques to process and interpret numerical data related to certification and educational standards. The qualitative analysis employed content analysis methods to examine research papers and journals, providing insights into trends, challenges, and best practices in dental technology education across different countries. This multifaceted approach ensured a thorough and nuanced understanding of the educational and professional landscapes of dental technicians in the selected countries, highlighting differences and similarities in their training, certification, and professional development.

Results

Digital courses

In modern dental technician education, digital education technologies are increasingly important. With the advancement of digital technology, many educational institutions in Japan, South Korea, Taiwan, and China have begun integrating digital technologies into dental technician training programs. For example, university programs related to dental technology have introduced CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) technologies to enhance students' practical skills and competitiveness. Over the past five years, digital fabrication centers have been established successively, and existing dental technology departments have shifted to focus primarily on digital processes. This indicates that dental technology has fully embraced digital procedures and will continue to develop vigorously in the future.

Dental technician training in the Philippines is completed through a degree program divided into levels I to IV. Eligibility for examination is achieved within two years. The training primarily focuses on fundamental clinical practical skills and does not include digital operations. Consequently, acquiring digital technology skills in the Philippines is likely derived from clinical practice.

China has been actively advancing its digital operational curriculum in education. However, the legislation for dental technicians in China is relatively new. Dental education in China is divided into dentistry, dental technology, and dental prosthetics technology. The digital courses are mainly concentrated in dentistry, while there are fewer CAD/CAM specialized courses in dental prosthetics technology. Nevertheless, digital equipment assistance remains prevalent in clinical operations, a trend somewhat akin to the situation in the Philippines.

National dental technician license examination

Taiwan

The Dental Technicians Act was legislated in 2010. Taiwan has two universities and three colleges of medicine of education offering dental technology-related programs. In order to be eligible for the national examination for dental technicians, the primary requirement is graduation from a dental technology-related program. For foreign qualifications, recognition by the Ministry of Education is necessary. Additionally, candidates must complete at least 144 h of internship within Taiwan. The examination consists of 14 subjects, including dental morphology, dental materials,

oral anatomy and physiology, fixed prosthodontics, ceramic prosthodontics, computer-aided design and manufacturing in dentistry, partial denture technology, complete denture technology, pediatric dental technology, orthodontic technology, regulations and ethics, and infection control. The written examination comprises four levels, each consisting of 50 multiple-choice questions to be completed in 60 min. Two subjects are assessed through practical examinations: tooth morphology carving and full denture arrangement, with a total duration of 240 min.

Japan

In Japan, The Dental Technicians Law was legislated in 1955, making Japan the first country in Asia to enact legislation specifically for dental technicians. Approximately 47 schools across Japan offer dental technology-related programs, including vocational schools with 2–3 years and universities with 4-year programs. Graduated students can take the national dental technician examination, consisting of written and practical tests. The written tests cover topics such as dental science and engineering, dental anatomy, oral physiology, removable prosthodontics, fixed prosthodontics, orthodontic technology, pediatric dental technology, and relevant regulations. The written exam consists of 80 multiple-choice questions to be completed in 120 min, with a passing grade of answering at least 48 questions correctly and a minimum passing rate of 30 % for each subject. Practical tests include three sections: tooth morphology drawing, basic 2D bending of orthodontic wires, and tooth morphology carving, with a duration of 120 min.

South Korea

The Medical Technicians Act in South Korea was enacted in 1973. Currently, there are 29 universities in South Korea offering departments related to dental technology. Those aspiring to become dental technicians must graduate from relevant departments and apply for the dental technician licensure exam, which is conducted annually. The dental technician licensure exam consists of written and practical tests covering topics such as basic dental technology knowledge, medical-related laws and regulations, and comprehensive dental technical skills. The written exam has two levels, with the first level comprising 95 questions and the second level comprising 110 questions, all multiple-choice questions with five options. The exam lasts 80–90 min, and candidates must achieve a minimum score of 40 % in each subject and an overall score of 60 % or higher to pass. The practical test involves manufacturing dental implants and lasts for 140 min.

Philippines

In 2007, the President of the Philippines issued laws concerning dental technicians and related matters. Currently, there are nine universities nationwide offering relevant departments. The dental technician licensure exam is divided into a three-day examination, with the first day consisting of theoretical tests covering basic medical and dental sciences, ethics and professional conduct review, removable denture restoration, and fixed denture restoration. The practical exam includes the fabrication of complete dentures, fabrication of partial dentures, orthodontic wire bending, fabrication of fixed dentures, and fabrication of non-metallic dentures.

China

In China, since 2006, the field of dental restoration craftsmanship has been categorized into five levels: primary technician, intermediate technician, senior technician, craftsman, and senior craftsman. Sichuan University is one of China's renowned dental technology schools, with over a hundred vocational schools or universities offering dental technology-related programs nationwide. Graduates from universities can pursue certification as senior craftsmen, while graduates from vocational schools must pass a national exam covering theoretical knowledge and practical skills in dentistry. The theoretical knowledge exam covers topics such as oral anatomy, oral pathology, dental materials, dental occlusion, and dental restoration techniques. The practical skills exam includes testing in oral radiography, dental model fabrication, fixed denture construction, and application of restorative materials. Since 2017, the examination has been conducted twice a year, with each session organized by local government authorities. The examination consists of both written and practical components. The practical tests emphasize the creation of wax models for dental diagnostic purposes and drawing tooth morphology, focusing on the maxillary incisors, maxillary canines, maxillary premolars, maxillary molars, and mandibular molars. The specific tasks in the practical tests are randomly determined for each examination cycle.

Discussion

Table 2 provides an overview of the examination outlines for dental technicians in five countries. Although the profession of dental technician is well-established in Europe and the United States, it is less developed in several Asian countries such as Singapore and Malaysia. Among the five countries analyzed, China was the most recent to establish regulations for dental technicians, with Taiwan following closely behind. Japan was the earliest among these Asian countries to create a formal structure for dental technicians. Thus, when Taiwan formulated its laws for dental technicians, it used Japan as a reference model,[12] establishing corresponding regulations and examination standards.

In the Asian region, the eligibility criteria for national examinations for dental technicians vary across different countries. In some countries, a small minority have relatively lenient examination requirements, necessitating only a basic educational background and practical experience to qualify for the exam, such as in China (Table 3). This leniency might result from a lack of training facilities in educational institutions, a shortage of professional clinical experience, or legislative flexibility. Among the five Asian countries discussed, the examination subjects also play a

Table 2 Comparison of dental technician examinations across countries.

Country	Taiwan	Japan	South Korea	Philippines	China
Quantity	5	47	29	18	100 up
Degree	College/ University	Vocation school/ University	Health university/ University	College/ University	Vocation school/ College/University
Pass rating average for the past 5 years	45.18 %	95.42 %	81.42 %	51.56 %	About 60 %
Examination category (number of questions/ total number of questions)	Theoretical exams (4/6) Practical exams (2/6)	Theoretical exams (1/2) Practical exams (1/2)	Theoretical exams (2/3) Practical exams (1/3)	Theoretical exams (4/9) Practical exams (5/9)	Theoretical exams (4/5) Practical exams (1/5)
Organizer	Examination Yuan	Ministry of Health, Labour and Welfare	Korea Health Personnel Licensing Examination Institute	Professional Regulation Commission	Ministry of Human Resources and Social Security of the People's Republic of China
Examination price (USD)	89.04	230.35	98.22	17.38	About 36.96[a]

[a] Fee standards vary across regional counties and cities.

crucial role. Consequently, in their search for talent, some countries impose higher requirements on candidates, including additional academic courses, longer clinical internship hours, and more extensive practical experience. These varying requirements reflect different countries' expectations for the professional level of dental technicians and their concern for oral health and safety.

Dental technology is a profession that heavily relies on specialized skills, and its cultivation process requires extensive hands-on practice and experience to become a professional dental technician. This contrasts markedly with other medical-related professions. A study in 2018 suggested that the education and evaluation system for dental technicians should incorporate practical content to strengthen relevance to clinical practice.[13] Given the focus on skills, practical examinations are part of the national exams to assess whether future dental technicians possess theoretical knowledge and competent professional skills. Japan's examination is more foundational among the five countries examined, while the examinations in the Philippines and China are more comprehensive. In 1974, South Korea became the first country in Asia to conduct practical examinations for dental technicians. As seen in Table 4, each country has different practical examination items. China, the Philippines, and South Korea offer more diverse subjects in their examinations. While the difficulty level may vary, these examinations have significantly enhanced overall skills among dental technicians. The examinations in Japan and Taiwan are more foundational, which helps to increase the number of dental technicians and address issues like clinical staffing shortages.[14–16] In 2016, Japan transitioned from county-specific examination items to a nationally unified examination structure.

Among the five Asian countries examined in this study, specialized dental technician schools or training institutions exist in each country, offering comprehensive curricula and internship opportunities to ensure that students acquire the necessary knowledge and skills. However, in China, educational institutions have established national uniform standards for high school vocational education, including curriculum design and classroom setup, which are not found in other Asian countries. There are differences in the dental technicians education systems among the five Asian countries. In China, training schools are not limited to medical-related institutions; they also include art schools and management schools. This diversity may be related to China's large population and its unique system for cultivating dental technicians. Vocational schools are eligible to participate in intermediate-level examinations, while university graduates or those with over seven years of relevant experience can take advanced-level examinations. These differences in education systems might also impact the professional development and employment prospects of dental technicians, underscoring the need to consider how to improve the quality and accessibility of education.

Dental technology is a highly specialized profession, and according to a 2018 survey, a lack of specialized skills has become one of the factors contributing to the difficulty young people face in finding employment.[17] Among the Asian countries examined in this study, there are no significant differences in the professional roles of dental technicians, except for variations in managerial institutions due to differences in national circumstances and cultures. For instance, in Taiwan, South Korea, and China, health and welfare-related agencies are primarily responsible for business management, whereas, in Japan and the Philippines, supervisory bodies are typically labor or employment-related departments. These differences reflect varying interpretations of the role and responsibilities of dental technicians in dental healthcare across different countries. Dental technicians are not involved in clinical diagnosis; instead, they rely on the

Table 3 Eligibility for the dental technician examination according to the laws of different countries.

Country	Eligibility for examination	Law name	Year
Taiwan	1. Graduates from dental technology programs or individuals with foreign dental technician licenses, provided they are recognized. 2. Individuals with a dentist's license or graduates from school of dental technology. 3. Completion of specified hours of clinical internship is required.	Dental Technician Act	2009
Japan	1. Graduates from dental technology programs or individuals with foreign dental technician licenses, provided they are recognized. 2. Individuals with a dentist's license or graduates from school of dental technology.	Dental Technician Law	1955
South Korea	1. Graduates from dental technology programs or individuals with recognized foreign dental technician licenses. 2. Individuals with a dentist's license or graduates from school of dental technology.	Act on Medical Technologists	1996
Philippines	1. Must be a Filipino citizen. 2. Graduates from dental technology programs or individuals with recognized foreign dental technician licenses. 3. Completion of clinical internship for at least 6 months. 4. He/She has completed the refresher course required after failing three consecutive licensure examinations. 5. One good moral certificate from any of the following: barangay, church, school, employer.	Act to Regulate the Practice of Dentistry, Dental Hygiene, and Dental Technology	2007
China	1. Current university or vocational school students or interns. 2. Individuals without relevant qualifications but employed in the industry, with certification from clinics or community hospitals. 3. Traditional Chinese medicine practitioners, physical therapy practitioners, and professionals in health, wellness, psychology, nutrition, and related fields. 4. After obtaining the intermediate vocational qualification certificate for this occupation, engage in this occupation continuously for more than 4 years, undergo formal training of the prescribed standard learning hours for this occupation at the senior level, and obtain a graduation certificate. 5. After obtaining the intermediate vocational qualification certificate for this occupation, engage in this occupation continuously for more than 7 years. 6. Obtain a certificate from a higher vocational school focusing on advanced skills recognized by the labor security administrative department or by a high-level technical school aiming to cultivate advanced skills. 7. Graduates with a diploma or higher in majors related to this occupation and who have been engaged in this occupation continuously for more than 2 years after obtaining the intermediate vocational qualification certificate for this occupation.	Implementation Measures of the Professional Qualification System for Health Professionals of the People's Republic of China	2017

Table 4 Practical examination durations and components by country.

Country	Taiwan	Japan	South Korea	Philippines	China
Exam duration	240 min	120 min	140 min	840 min	550 min
Examination items					
Complete denture fabrication[a]				V	
Complete denture teeth arrangement	V				
Dental technology[b]			V		
Fixed partial denture fabrication[a]				V	
Line drawing of teeth		V			V
Metal free fabrication[a]				V	
Orthodontic device fabrication[a]					
Removable partial denture fabrication[a]				V	
Teeth morphology curving	V	V			V
Wire bending		V		V	

[a] Each examination has a different set of items.
[b] Five questions each on fixed dentures, removable partial dentures, complete dentures, and complex dentures; one question would be selected for each exam.

diagnoses and treatment plans provided by dentists to carry out prosthesis fabrication.

International cooperation and trends among Asian countries are crucial in the training and practice of dental technicians. These countries can improve the professional standards of dental technicians through participation in international organizations, attendance at international conferences, and exchange of experiences. By participating in organizations such as the International Association for Dental Research (IADR) and engaging in international seminars, countries can learn from best practices in other regions and share their own insights. Additionally, with the continuous advancement of technology, dental technology is encountering new challenges and opportunities, including 3D printing and digital design. These trends are likely to influence the training and practice of dental technicians across countries, underscoring the need for ongoing adjustments and updates to relevant policies and requirements.

This study shows that many countries have established dental technology programs in colleges or universities. This indicates that dental technology isn't a profession that can be adequately cultivated solely through vocational schools. Even if the learning objectives are met, they may not align with higher education goals. With the advent of digitalization, the dental technology industry is undergoing a significant transformation, evolving from traditional plaster model fabrication of prosthetics to fully digital design and milling. Artificial intelligence is expected to assist dental technicians in completing most tasks in the foreseeable future. Professionals with specialized skills will be crucial in refining products, performing realistic simulations, and conducting quality control throughout prosthetics manufacturing. Educational institutions should incorporate more courses focused on digital processes while maintaining traditional hands-on training. Integrating digital learning methods will ensure that students become more proficient in practical skills, thus minimizing the gap when transitioning to clinical practice.

With the rise and implementation of digitalized education, the dental technology industry has thrived through advancements in digital technology. However, the results of this study indicate that practical examinations in five countries do not incorporate digital processes. This may be due to the emphasis on basic clinical skills in national examinations, which are considered fundamental. Operating digital equipment involves fewer manual skills and requires more specialized knowledge to fabricate prostheses using digital tools.

A comparative analysis of national examinations, educational systems, and professional roles for dental technicians in Asian countries reveals the potential for strengthening international cooperation. Sharing successful experiences and lessons learned can foster mutual growth within the industry. This collaboration could be facilitated through involvement in international dental technology associations and the organization of international seminars and workshops.

Adapting to new technologies has become crucial in this rapidly evolving technological era. We should respond to technological changes by providing students with the necessary technical training to meet the demands of emerging technologies and digital design. Regular updates to training programs that reflect the latest technological developments are essential to ensure students acquire the required skills. While dental technicians' training and examination systems vary across Asian countries, these differences offer opportunities for mutual learning. By fostering international cooperation, enhancing educational quality, adapting to new technologies, and establishing unified standards, the development of the dental technology industry can be advanced, ultimately improving oral health and benefiting patients. Future research and practice should continue to focus on this critical field to refine policies and practices further, thereby achieving higher professional standards for dental technicians.

This study underscores the critical role of integrating digital technologies in dental technician education across several Asian countries, including Japan, Taiwan, South Korea, the Philippines, and China. Our comparative analysis of national examination standards reveals significant differences in educational systems and professional roles. Despite these variations, there is a common commitment to ensuring high professional skills and knowledge among

dental technicians. Digital technologies, while increasingly incorporated into dental technician training programs, are not yet fully integrated into practical examinations. This highlights the urgent need for educational reforms to bridge the gap between traditional training methods and modern digital practices. By adopting a balanced approach that combines digital learning with traditional hands-on training, educational institutions can better prepare students for the demands of the dental technology industry.

Furthermore, international cooperation and knowledge exchange through professional associations and seminars are vital for mutual growth and the elevation of industry standards. In the future, countries should also work towards standardizing the title of dental technicians. Continuous updates to training programs, reflecting the latest technological advancements, will be crucial in aligning educational outcomes with clinical practice needs. Adapting to new technologies and fostering global collaboration will be pivotal in promoting the future professional development of dental technicians, ultimately enhancing oral health outcomes for patients.

Declaration of competing interest

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

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