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## Teacher Competencies and Professional Learning in Technology-Based Vocational Education and Training Music Education: A Research Review

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**Abstract.** This paper discusses teacher competencies and professional development issues in technology-based music education related to Vocational Education and Training (VET) music teaching, focusing on VET colleges in China. Over the past years, VET music programs have undergone tremendous changes in technology and have produced new technology-based music courses, such as music editing and music production with a digital audio workstation. All of these have put some new demands on music teachers in music, pedagogy, and technology knowledge. The integrative literature review method has synthesized the relevant literature. The PRISMA 2020 reporting guidelines guided the search and screening process to make transparent its steps and results. Three structured search engines Scopus, Web of Science, and Google Scholar were applied to identify relevant literature published between 2020 and 2025. Of 485 records identified in the initial search, 20 studies were included in the final synthesis after screening their titles, abstracts, and full texts (n = 20). Results show that existing research conceptualizes music teacher competencies through three unintegrated dimensions of musical, pedagogical, and technological competencies. In addition, professional learning was frequently organised as short-term workshops rather than sustained, practice-based development models. The review also reveals limited research on technology integration in VET music pedagogy within the Chinese context. These findings highlight the need for more integrated competency frameworks and sustained professional learning models to support technology-based music education in Chinese VET colleges.

**Keywords:** Music teacher competencies; Digital music education; Professional learning; VET

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## 1. Introduction

Digital technologies are increasingly transforming teaching and learning in vocational education. In Vocational Education and Training (VET), music teachers are expected to combine musical expertise, pedagogical knowledge, and technological skills in their teaching practice. This expectation is particularly evident in VET colleges in China, where music programmes increasingly include digital music courses such as music editing and digital audio workstation-based production. These developments require teachers to adapt their instructional practices to technology-rich learning environments while responding to industry-oriented training needs.

Previous studies often explain teacher competencies for technology integration through the interaction of technology, pedagogy, and content knowledge. The Technological Pedagogical Content Knowledge (TPACK) framework is widely used to describe how teachers integrate digital tools into teaching (Wibowo et al., 2022). However, VET music education frequently extends beyond classroom instruction and includes activities such as digital music production and project-based learning. As a result, existing competency frameworks may not fully capture the industry-oriented and practice-based nature of teaching in Chinese VET music programmes (Xue, 2023; Yan & Jamaludin, 2025). In addition, professional learning is an important mechanism for developing teachers' technology-related competencies, yet many studies focus mainly on short-term training activities rather than sustained, practice-based professional learning.

Despite increasing attention to technology integration in education, limited research has synthesised how teacher competencies and professional learning are addressed specifically in VET music education, particularly in the context of Chinese VET colleges (Setiyawan et al., 2025). To address this gap, this study conducts an integrative literature review to examine existing research on technology-based VET music education (Demissie et al., 2022).

The review aims to answer the following research questions:

**RQ1:** How are teacher competencies for technology-based music education conceptualised in VET contexts?

**RQ2:** How is professional learning for technology integration in VET music education described and organised across studies?

**RQ3:** What key challenges are reported regarding the development of music teachers' competencies for technology-based teaching?

By synthesising existing studies, this review provides a clearer understanding of competency frameworks, professional learning practices, and the challenges associated with technology-based music education in Chinese VET colleges.

## 2. Literature Review

### 2.1 Technology-based Music Education in VET Contexts

Thus, (Antera, 2021) notes that the use of technology goes beyond the moment of contact with digitized objects and includes changed pedagogical approaches and revised learning practices. According to (Petkova, 2023), information technology

enables instrumental learning for music and organizes various learning activities. However, considerable concern must be devoted to the objectives of the courses, as well as the differentiation of the concepts regarding the students. Thus, technology includes hardware, software, and online platforms, and it gradually becomes part of everyday teaching practice rather than a separate addition.

Petkova also says that although information technology supports music skills and develops learning, at the same time, it requires due considerations from the instructor based on learner diversity and course objectives (Petkova, 2023). Embedding technology in Vocational Education and Training will be based on the staggered incremental approach: first, equipping teachers with hardware and digital music application software with simple tutorials; second, the physical embedding of the technology into the curricula and pedagogical practice; and finally, the actual embedding of technology in practical activities like creating, performing, and producing music by teachers and students (Zhang & Sui, 2017). Music education is strongly shifting toward very many forms of e-Massive Open Online Courses (MOOCs) Small Private Online Courses (SPOCs), as well as many computer applications affecting music teaching, learning, and production. Thus, music publishing and distribution have modified the relationship between teachers and learners (Xue, 2023).

According to (Karkina et al., 2023), the teaching process in VET is practically oriented towards job applications and involves an explicit development of practical skills; most activities are related to performing music and technologically mediated creation and production activities. Such blending Calls for teachers to integrate digital technologies, classroom management mediators, and continuous pedagogical adjustments according to student variability. The theoretical knowledge, instrumental training, and creative work might be considered part of the blended learning process using DAWs, notation software, and web services (Marín-Suelves et al., 2022). Most of the instruction combines music performance with technology-supported creation and production (Yusupova & Rakhmonova, 2022).

Current literature demonstrates that music education in this digitalized mode rests upon institutional and policy parameters of Chinese VET. It is introduced as a general digital music production course and other technologically oriented courses at higher levels in China. However, sharp institutional contradictions regarding the concept of integration exist even when integration occurs (Xue, 2023; X. Zhang, 2019). Thus, at the institutional level, computer facilities and software are abundantly supported, but only a few institutions can provide the necessary conditions to overcome structural demands, such as those related to the outline structure and teacher training (Wan, 2022; Zhong, 2023). This will thus lead to specific uses of music in teaching and teacher-professional challenges in such VET environments (Yan & Jamaludin, 2025).

Compared with general higher education or basic education, VET music education shows clear differences in both teaching goals and technology use. TVET teachers are expected not only to deliver content but also to support

personalised and collaborative learning through technology, with a strong focus on vocational competence development (Abd Wahab et al., 2024). Technology use is therefore closely aligned with industry practices and real work processes. This orientation highlights the practice-based nature of technology-based music education in VET settings and raises important questions about how teachers develop the competencies required for technology integration (Antera, 2021; Setiyawan et al., 2025).

Within this technology and practice-based environment, how teachers understand and develop their competencies for technology integration becomes a key issue in VET music education. This concern has led researchers to conceptualise music teachers' competencies from different theoretical perspectives.

## **2.2 Literature Conceptualizations of Music Teacher Competencies for Technology Integration**

Research on teacher competencies for technology integration in music education has developed along several theoretical perspectives. In VET contexts, these perspectives generally fall into three broad approaches: structured knowledge-based frameworks, digital competence models, and situated views of professional competence. Each approach reflects different assumptions about how teachers develop and apply competencies for technology-based teaching, and they often reveal differences between general education and vocational education contexts (Petkova, 2023).

One of the most widely used frameworks for understanding teachers' technology-related competencies is the Technological Pedagogical Content Knowledge (TPACK) model (Xue, 2023). TPACK conceptualizes teacher competence as the integration of technological knowledge, pedagogical knowledge, and subject content knowledge (Wibowo et al., 2022). Their integration is seen as the basis for appropriate technology use in teaching (Wibowo et al., 2022; Zhong, 2023). What follows includes music education literature, where digital musical instruments and the production process have to be aligned with specific teaching and learning goals to meaningfully facilitate and enhance student learning within the classroom (Xue, 2023). Recently, studies have also explored how emerging technologies such as artificial intelligence (AI) expand the competencies required of teachers, particularly in designing technology-supported learning environments and managing AI-assisted learning processes (Fan, 2024; Setiyawan et al., 2025).

Another group of studies conceptualises teacher competence from a digital competence perspective. Frameworks such as Digital Competence Framework for Educators (DigCompEdu) define teacher competence as a broad set of abilities that go beyond technical skills and include the selection, use, and reflection on digital resources in teaching contexts (Domínguez-González et al., 2025). While this perspective broadens the understanding of teacher competence, studies in vocational education suggest that general digital competence frameworks may not fully capture the industry-oriented demands of VET teaching practice (Abd Wahab et al., 2024).

At the same time, several studies emphasise a situated and developmental understanding of teacher competence. From this perspective, vocational teacher competence is closely linked to authentic teaching tasks and professional practice. Teachers develop technology-based competence through engagement with real instructional challenges and changing teaching contexts, rather than through the acquisition of isolated knowledge components (Antera, 2021; Yi & Mazlan, 2024). In this sense, in music education, the recent inquiry dealt with teachers' professional judgment on technology use in supporting music making, performing, and collaborative learning (Petkova, 2023).

These conceptual tensions become much clearer in the context of Chinese VET music education. Recent studies on higher vocational colleges in China find that while structured models, such as TPACK, provide useful analytical categories, they often need local adaptation to make them relevant to local institutional conditions and teaching realities (Xue, 2023; Zhong, 2023). General digital competence frameworks covering wide applicability do not take resource, curriculum design, and teacher training constraints in the Chinese VET context into account (Wan, 2022). The situated approach asks for greater practical relevance but does not make so systematic a description of the competence components. Such differences are reflected in the understanding of teacher competencies in Chinese VET music education and signal the need for more context-sensitive conceptualizations.

### **2.3 Professional Learning for Technology Integration in VET Music Education**

Given this, professional learning in this study integrates the acquisition, application, and elaboration of competencies through technology by teachers in a continuous, dynamic process. In this light, professional learning supports technology integration in teaching practice, during which teachers transform their pedagogical roles and practices (Ho, 2009). Although the literature does not always explicitly classify professional learning approaches, several main pathways can be identified based on reported practices and organisational forms (Wan, 2022; Yi & Mazlan, 2024).

The most common professional learning form is training, which fosters various competencies in the use of digital tools and software (Hassan et al., 2021). Several studies estimate that professional learning mainly starts with training in hardware and different digital music technologies: multimedia equipment, presentation software, and audio-visual equipment (P. Zhang & Sui, 2017). In this respect, technical training can develop teachers' competencies, but several studies found that such training was mostly of a short duration and tool-based, reducing teachers' chances to integrate technology into their teaching practices over time (Sheffield et al., 2018; Wan, 2022).

Collaborative learning, which is considered an advanced form of professional learning, helps develop technical integration competencies through interaction among and within teachers and from teachers to students (Asmayawati et al., 2025). In that sense, digital music technology does place people in a situation to collaborate practically. Several activities related to music creation and the

application of technology audiovisual dubbing projects and mobile music ensembles are completed through collaboration (P. Zhang & Sui, 2017). Thus, cloud-based music courses use resources in the form of blogs and forums to facilitate contact and resource sharing, allowing collaboration to play a vital role in constructing knowledge and developing competencies (Zou, 2020).

Communities of practice provide a more sustained environment for professional learning. Research suggests that cross-art activities, continuing education programmes, and extracurricular practices, such as interest groups, art visits, and competitions, extend classroom teaching and support shared learning experiences among teachers and students (Abdurahmanovna, 2020). In the context of Chinese VET music education, some studies report that educational cloud platforms and digital resource systems support resource integration and sharing, which can contribute to the development of practice-based learning communities (Wan, 2022). However, the formation of such communities often depends on individual initiative, and institutional support remains limited in many cases (Yan & Jamaludin, 2025).

Overall, the literature suggests an implicit progression in professional learning for technology integration, moving from basic technical training to collaborative practice and sustained participation in communities of practice. Training provides foundational skills, collaborative learning supports the integration of technology with music teaching content, and communities of practice enable the regular use of technology in teaching. Without sustained support and context-sensitive learning opportunities, professional learning may not adequately support teachers' competency development in technology-based VET music education (Fan, 2024; Sheffield et al., 2018).

### **3. Methodology**

This study conducted an integrative literature review and synthesis on teacher competencies and professional learning in technology-based pedagogical practices of VET music education under the descriptive guiding framework of PRISMA 2020 (Page, Moher, et al., 2021). The rationale is that PRISMA guidelines may serve as a reporting tool, not a functional guideline, for systematic reviews. The review thus focused on conceptualizing teacher competencies, organizing professional learning, and problematizing challenges in the literature. Beyond that, the search procedure, inclusion and exclusion criteria, and study selection processes are summarized below, following (Elnaffar et al., 2026).

#### **3.1 Search Strategy**

This study conducted a systematic literature search using three major academic databases: Scopus, Web of Science, and Google Scholar. These databases were selected to ensure broad coverage of research related to education, vocational education and training (VET), and technology integration in music education. This combination of databases enables a systematic and representative search strategy and has been widely cited in review studies within the field of education (Yang, 2025).

Scopus was chosen because it indexes a wide range of peer-reviewed journals and conference proceedings from a wide range of disciplines, including education, technology, and music studies. Web of Science was included due to its high indexing standard and excellent database coverage of key impact journals and conference proceedings related to education and other closely related disciplines. Google Scholar was added to the other databases to allow more comprehensive retrieval of scholarly materials, especially conference papers and new research, which are probably hidden in large citation indexes.

Based on the search, a total of 288 records were identified from Scopus, 24 from the Web of Science, and 173 from Google Scholar, thus a total of 485 records. This is because such a search strategy in these databases has considered the possibility of maximising coverage while ensuring relevance and hence the possibility of good quality and reliable studies. This followed a multi-stage review process after scanning titles and abstracts, full-text review was carried out. It was considered necessary to review the literature's relevance concerning technology-based music education in VET settings, competencies, and professional learning of teachers. Exclusion was based upon criteria if the texts did not provide any additional information relevant to the research questions or were otherwise not accessible in full text. Full-text screening resulted in 20 papers being synthesized finally. To clearly describe the process and ensure transparent methods, the screening of studies was presented in a PRISMA-style flow diagram.

### 3.2 Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were developed to guide the process of selecting the most relevant studies for the topic of this integrative review. These have been employed to define thematic relevance rather than as a basis for appraising the quality of research. A summary of the inclusion and exclusion criteria is provided in Table 1.

**Table 1: Relevance of objectives of teaching subjects at the university**

<b>Criterion</b>	<b>Inclusion</b>	<b>Exclusion</b>
<b>Publication type</b>	Peer-reviewed journal articles and conference papers	Non-peer-reviewed publications (e.g., editorials, opinion pieces)
<b>Language</b>	English	Non-English publications
<b>Time period</b>	Published between 2020 and 2025	Published before 2020
<b>Educational context</b>	Studies related to vocational education and training (VET/TVET)	Studies unrelated to vocational or practice-oriented education
<b>Disciplinary focus</b>	Music education or music-related teaching contexts	Studies unrelated to music education
<b>Research focus</b>	Teacher competencies or professional learning for technology integration among pre-service and in-service music teachers	Studies focusing solely on student outcomes or technology tools without teacher focus
<b>Full-text availability</b>	Full text accessible	Full text not accessible

Studies were included if they addressed music education within vocational education and training (VET or TVET) contexts and examined issues related to teacher competencies and or professional learning in relation to technology integration. Eligible studies were required to focus on music teachers or music-based teaching contexts and to explore teacher competencies, digital skills, professional learning processes, or teaching practices influenced using digital technologies. Both pre-service and in-service teacher studies were included, provided that the educational context was clearly linked to vocational or practice-oriented education systems (Yi & Mazlan, 2024).

### **3.3 PRISMA-style Flow Diagram**

PRISMA is commonly used as a reporting tool in review studies to present the process of literature identification, screening, and inclusion in a transparent manner (Page, McKenzie, et al., 2021). In education research, PRISMA-style flow diagrams are often employed to visualise multi-stage study selection processes and to clarify how the final body of literature is derived (Yi & Mazlan, 2024).

In this study, a PRISMA-style flow diagram was used to illustrate the literature selection process. As shown in Figure 1, a total of 485 potentially relevant records were identified through database searches in Scopus, Web of Science, and Google Scholar (Jamal et al., 2026). After the removal of duplicate records, the remaining studies were screened based on their titles and abstracts to assess their relevance to technology-based music education in VET contexts.

### **3.4 Study Selection Process**

After the database search, 485 records were retrieved from Scopus, Web of Science, and Google Scholar. The screening process was performed only after the removal of all duplicate records. To ensure consistent applicability, screening was performed by one reviewer who determined the level of study relevance. Titles and abstracts were screened to determine whether the topics included music education, vocational education and training contexts, and teacher competencies or professional learning issues.

Studies not addressing music education or a VET context or not including any teacher-related focus were excluded. After this first screening, 218 articles were eligible for full-text retrieval, but 21 could not be obtained in full; thus, 197 underwent full-text screening.

The inclusion and exclusion criteria were applied during the full-text review to ensure that the study was conducted within an education context, teacher competencies were related, and the teaching context involved technology. Subsequently, 177 studies were excluded as they did not relate to music in vocational education and training, considered teacher competencies or professional learning to an insufficient degree, or were outside the scope of teaching with technologies. Ultimately, 20 studies included all criteria and contributed to an integrative synthesis. A PRISMA-style flowchart (Figure 1) shows this selection process in detail (Page, McKenzie, et al., 2021).

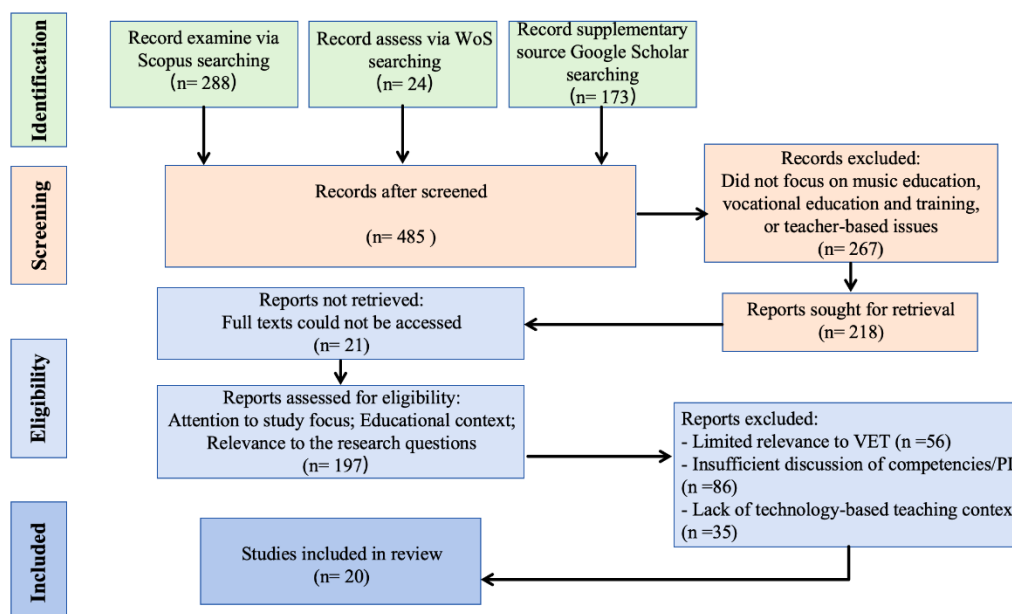


Figure 1: PRISMA-style flow diagram of the study selection process

### 3.5 Data Extraction and Analysis

Data from the 20 sampled studies were extracted using a review matrix to compare the literature systematically. The matrix was designed to capture key information pertinent to the research questions, including the author/year of publication, educational context, study focus, conceptual frameworks, conceptualisations of teacher competencies, professional learning approaches, and related challenges. Next, the data would be analysed following a thematic synthesis approach. This involved identifying recurring concepts from the data across studies, grouping these concepts into categories, and then synthesising these categories into themes related to each of the three research questions (RQ1–RQ3).

The themes related to RQ1 concerned various conceptualisations of teacher competencies, perspectives based on knowledge, digital competence, and situated perspectives. Themes relevant to RQ2 concerned conceptualisations of professional learning, such as training-based, collaborative, and practice oriented professional learning. Themes related to RQ3 concerned the challenges teachers face in integrating technology into their teaching.

This approach afforded this study a basis on which to identify patterns across studies and has been useful for organising the interpretation of the findings. The data extraction and coding framework is summarised in Table 2.

**Table 2: Inclusion and Exclusion Criteria for the Reviewed Studies**

Review Focus	Extracted Data	Coding Focus	Related RQ
Study profile	Author, year, country, educational context	Descriptive mapping	General
Teacher competencies	Definitions, frameworks	TPACK, digital competence, situated competence	RQ1
Professional learning	Forms, activities, organization	Training, collaborative, practice-based learning	RQ2
Challenges	Barriers to technology integration	Individual, institutional, contextual challenges	RQ3
Synthesis outcome	Cross-study patterns	Theme development	RQ1-RQ3

#### 4. Results and Discussion

Twenty (20) peer-reviewed articles were selected through the integrative literature review and analysed according to PRISMA reporting guidelines (Page, Moher, et al., 2021). The analysis was thus not designed to aggregate empirical outcomes but rather to interpret the conception of teacher competencies and professional learning for technology-based music education within different institutional and national contexts, especially in VET colleges in China. The data extracted from these 20 papers are summarized in Table 3, Showing Focus and Outcomes, presenting each paper's focusing issue and outcome in a constructive statement.

**Table 3: Key finding analysis from 20 selected papers**

No.	Paper (Authors, Year)	Educational Context (VET/Country)	Conceptualization of Teacher Competencies (RQ1)	Professional Learning Focus (RQ2)	Key Challenges Identified (RQ3)
1	(Abdurahmanovna, 2020)	Music education	Conceptualizes competence as adapting traditional music teaching to digital contexts.	Supports learning through blended and technology-enhanced approaches.	Tension between tradition and digital innovation.
2	(Abd Wahab et al., 2024)	TVET Malaysia	Competence conceptualized as developing both technical and pedagogical skills, enhancing self-efficacy, professional identity, and bridging theory-practice gaps.	Focus on structured professional development programs, digital skills, and practical teaching strategies.	Novice teachers face challenges adapting to evolving curricula, technology integration, diverse student needs, and limited structured support.
3	(Antera, 2021)	Vocational education, Europe	Defines competence as situated, developmental professional judgment linked to authentic vocational action.	Emphasizes learning through practice, reflection, and workplace engagement.	Difficulty translating abstract competence models into

					practice-based development.
4	(Chunhong et al., 2025)	Higher education with AI / China and international	Conceptualizes teacher competence broadly as AI-related teaching capability, including digital literacy, instructional design, and ethical awareness, rather than subject-specific skills.	Highlights professional learning through institutional training, policy-driven initiatives, and blended learning models for AI adoption.	Identifies lack of pedagogical depth in AI use, limited teacher preparedness, and weak alignment between AI tools and teaching objectives.
5	(Civit et al., 2022)	Music technology research / international	Does not define teacher competence directly but implies competence as the ability to understand and critically engage with AI-based music generation tools.	Suggests professional learning through experimentation, research engagement, and exposure to emerging AI music technologies.	Points to the complexity of AI systems, limited pedagogical guidance, and uncertainty about educational relevance in music teaching.
6	(Domínguez-González et al., 2025)	Teacher education, multi-country / Europe	Frames teacher competence through digital competence models, defining competence as a combination of technical, pedagogical, and ethical dimensions rather than subject-specific expertise.	Emphasizes continuous professional learning aligned with competence frameworks, including formal training, reflective practice, and institutional support.	Identifies fragmentation between policy-level competence frameworks and teachers' classroom realities; uneven implementation across contexts.
7	(Fan, 2024)	Music teacher development, China	Conceptualizes competence as AI-supported teaching capability.	Highlights AI-assisted professional development models.	Limited teacher readiness and ethical concerns related to AI use.
8	(Fooladi et al., 2025)	Teacher education, multidisciplinary / Norway	Defines competence as interactional and relational, focusing on teachers' professional judgement, coherence, and ability to support learning through classroom interactions.	Emphasizes professional learning through guided observation, feedback, and collaborative reflection using structured frameworks.	Notes challenges in transferring abstract interaction frameworks into daily teaching practice and sustaining coherence across disciplines.
9	(Gül, 2023)	Music education	Conceptualizes competence as effective use of technology-supported teaching tools.	Supports learning through classroom experimentation.	Limited pedagogical guidance for technology use.

10	(Hassan et al., 2021)	TVET, multi-country	Frames competence through ICT skills, pedagogical adaptation, and institutional readiness.	Highlights formal ICT training and infrastructure-supported learning.	Unequal access to ICT resources and limited teacher training coverage.
11	(Kibici, 2022)	Music education, mixed levels / Turkey	Conceptualizes teacher competence as perceived technological competence, including basic digital skills and the ability to integrate music software into teaching practice. Emphasizes teachers' self-perception rather than formal frameworks.	Highlights informal and experience-based professional learning, mainly through self-directed exploration of music technologies and peer support.	Reports gaps between teachers' positive attitudes toward technology and their limited practical integration skills; lack of structured professional learning support.
12	(Petkova, 2023)	Music education, higher education	Conceptualizes competence as functional and creative use of digital music technologies.	Supports learning through experimentation with digital tools.	Gap between technological functionality and pedagogical depth.
13	(Setiyawan et al., 2025)	Vocational education (TVET) / multi-country (incl. China)	Conceptualizes competence using the AI-TPACK framework, defining teacher competence as the integration of AI-related technological, pedagogical, and content knowledge in vocational contexts.	Focuses on structured professional learning for AI integration, including targeted training programmed and assessment-informed development pathways.	Highlights teachers' limited AI readiness, lack of AI-specific training, and difficulties aligning AI tools with vocational teaching tasks.
14	(Tian & Tian, 2025)	Higher vocational music education, China	Frames competence as the ability to use immersive technologies (VR) for skill training.	Emphasizes experiential and technology-enhanced learning.	High cost and limited scalability of advanced technologies.
15	(Wan, 2022)	Vocational education, China	Indirectly frames competence through teachers' support of students' digital engagement.	Emphasizes informal learning and classroom-based adaptation.	Low digital competence among students and teachers.
16	(Wibowo et al., 2022)	Music education, vocational contexts	Conceptualizes competence via TPACK as integrated technological, pedagogical, and musical knowledge.	Emphasizes structured professional learning aligned with TPACK components.	Teachers' imbalance across TPACK dimensions.
17	(Xiong, 2025)	Music education / China	Conceptualizes teacher competence as the	Emphasizes professional	Identifies exam-oriented systems,

			ability to apply multiple intelligences theory in music teaching, including adaptive pedagogy and learner-centred design, rather than technological mastery.	learning through reflective practice, theory-informed teaching, and contextual adaptation in Chinese classrooms.	lack of assessment tools, and limited resources as barriers to implementing innovative approaches.
18	(Xue, 2023)	Higher vocational music education, China	Frames competence as applied TPACK aligned with industry-standard music technology.	Highlights practice-oriented professional learning.	Insufficient industry-aligned training opportunities.
19	(Yan & Jamaludin, 2025)	VET, China & Malaysia	Defines competence through policy-driven vs industry-driven qualification systems.	Compares structured policy-led training and flexible industry-led learning.	Structural constraints and cross-national inconsistency.
20	(Yi & Mazlan, 2024)	Music teacher education	Defines competence as a combination of pedagogy, reflection, and digital awareness.	Highlights reflective and competency-based professional learning.	Lack of systematic support for sustained development.

#### 4.1 Findings Teacher competencies for technology-based music education in VET contexts conceptualized

The reviewed literature showed that teacher competencies for technology-based music education in VET contexts are conceptualized through several distinct pathways rather than a single unified model. Across the reviewed literature, these pathways are not equally represented, with knowledge-integration frameworks appearing most frequently.

##### 4.1.1 Two authors Major Pathway: Policy and system driven, framing teacher competencies through national vocational education structures

In the Chinese context, teacher competencies in higher vocational music education are strongly shaped by the policy driven “dual qualified teacher” model. This model requires teachers to possess both pedagogical credentials and industry-based professional skills and emphasises enterprise placements, centrally organised training, and unified qualification standards (Yi & Mazlan, 2024). Competency development is therefore closely embedded in state regulation and reflects the strong policy steering characteristic of China’s VET system. This is in marked contrast, however, to a comparatively flexible, industry-responsive approach in Malaysia (Yan & Jamaludin, 2025), such as the Training of Trainers certification system and National Dual Training System, which facilitate close collaboration between college teachers and industry mentors and provide graduates with several professional development options (Yan & Jamaludin, 2025).

*4.1.2 Dominant pathway: Knowledge-integration frameworks, with TPACK and its extensions as the main reference*

Recent extensions, such as Artificial Intelligence-Technological Pedagogical Content Knowledge (AI-TPACK) (Giam, 2025), further specify teacher competencies as combinations of AI-related technological knowledge (AI-TK), pedagogical knowledge (AI-PK), and content knowledge (AI-CK), along with their intersections. These models emphasise teachers' capacity to align digital and AI tools with industry standards, skill operations, and instructional goals in vocational music education (Setiyawan et al., 2025).

Similarly, research on music teacher competencies conceptualises technology-based competence through dimensions such as technical literacy and the ability to integrate technology into classroom practice, highlighting that technical proficiency alone is insufficient without alignment with musical content and pedagogy (Kibici, 2022). Although this pathway provides relatively clear structural models, variations in how competency dimensions are defined and operationalised weaken conceptual coherence across studies. Across studies, TPACK-based frameworks remain the dominant reference point, although their application varies considerably across contexts.

*4.1.3 This Third pathway: This approach draws upon theories specific to music education and emphasizes the contextual, value-laden character of teacher competencies*

The signature pedagogic-focused literature views music teachers' competencies in a three-layer architecture. The surface structure concerns the visible teaching practices and the acquisition of musical skills; the deep structure includes pedagogical reasoning and professional thinking, while the implicit budget deals with values, ethics, and identity issues (Gül, 2023). From this perspective, music education is concerned with skills and artistic and moral values; thus, pedagogical technology mediates the places of education and hinders the development of implicit structures because, in this case, the surveillance of values is not so immediate within the face-to-face setting (Karkina et al., 2023).

*4.1.4 Implications for Theory and Practice in Chinese VET Music Education*

In Chinese VET colleges, these tensions are further shaped by strong policy steering, uneven institutional resources, and close alignment with industry skill demands. Together, the findings indicate the need for more integrative conceptualisations that can bridge structural competency frameworks with situated vocational practice and the distinctive characteristics of music education (Wan, 2022). Compared to technology-focused models, this approach places greater emphasis on values and identity, revealing a conceptual gap in existing competency frameworks. This suggests that in Chinese VET contexts, competency frameworks need to be localised to integrate policy requirements, technological competencies, and the value-oriented nature of music education.

**4.2 Professional learning for technology integration in VET music education described and organized across studies**

The reviewed literature described professional learning for technology integration in VET music education as being organized through multiple, often overlapping approaches. Several studies reported structured training

programmes that focus on the application of digital technologies in music education. These programmes commonly adopted practice-oriented, small-group formats over a short period and combine face-to-face instruction with online resources, such as MOOCs. Their main aim is to support teachers' transition from theoretical understanding to technology-supported music practice (Wan, 2022).

Other studies emphasized platform-based professional learning. Customized digital platforms support collaborative learning by allowing teachers and students to upload, share, and annotate music performances. These platforms create environments in which professional learning develops from shared practice rather than primarily from formal instruction through social interaction and feedback (Yee-King et al., 2019). Studies on novice VET teachers also showed that professional learning is generally organized through courses, workshops, mentoring, peer networks, and digital learning communities, thus stressing the need for structured and continuous development pathways (Abd Wahab et al., 2024).

These professional learning formats discussed above suggest different processes of building competencies. Practice-led group training may partake in building competencies of creativity and communicative and reflective thinking through digital tools, web-based platforms, and emerging technologies (Abdurahmanovna, 2020). Platforms enable collaborative learning and emphasize feedback, interaction, and shared reflection as elements in intertwining technological and musical practice. Face-to-face and online blended elements tend to foster technical skills, contribute to the development of professional identity, and enhance autonomy in teaching (Fooladi et al., 2025). Most professional learning programs call for sustained practice through mentoring and feedback, rather than 'one-off' training for the gradual integration of technology into VET music teaching (Fan, 2024).

#### **4.3 Significant challenges indicated in the existing literature related to the development of music teachers' competencies in technology-based teaching**

At an individual level, lack of digital proficiency has frequently been mentioned as a key barrier. For example, music teachers with limited previous experiences with digital technologies have faced significant challenges in adapting to technology-based and online teaching. Although most teachers are willing to get better through professional development or self-learning, digital skill gaps sometimes diminish confidence in technology use and make new technology adoption difficult (Gül, 2023).

At the organizational level, underdeveloped infrastructure and impossible professional development directly impact the competencies that can be developed. Insufficient equipment, an unstable platform, and no long-term training opportunities will prevent teachers from effectively practicing new competencies (Kibici, 2022). Contextual factors limit the lived experience of teachers. Lack of time, classroom control, and students are usually high on the list of complaints (Setiyawan et al., 2025). This is generally the case in smaller or more isolated communities, where classroom management and control over virtual learning

space become more challenging and thus increase the resistance factor to the pedagogical change process (Váradi et al., 2023). Indeed, such mutual reinforcement of problems could appear such that organizational limits call into question individual competencies, whereas contextual limits demoralize and reduce even further the opportunities of teachers to engage in professional learning. This situated the need for embedded multisite support around skills, institutional conditions, and teaching settings.

## **5. Conclusion**

This integrative review examined how teacher competencies and professional learning are conceptualized in technology-based music education within VET contexts, with a focus on Chinese VET colleges. The findings show that current competency frameworks remain structurally fragmented, with limited alignment between policy-driven models, knowledge-integration frameworks, and situated vocational practice. Professional learning is predominantly organized as short-term, practice-oriented training, while sustained and practice-based models remain underdeveloped.

This review, therefore, places the conceptual and contextual competency frameworks within approaches to digital competences and situated practice, arguing for more context-sensitive and practice-oriented conceptualizations. This means that for the development of VET music education in China, curriculum design should be enhanced, industry cooperation expanded, and continuous professional learning systems or opportunities must be nurtured to integrate technologies adequately and, by extension, the new AI-related competencies.

This synthesis has led to the conclusion that teacher competency development in VET colleges of China has been called to handle both technological and human dimensions. Some drawbacks are, therefore, noted regarding the limitation of this review to English-language publications and the small number of studies included ( $n = 20$ ), which limit the applicability of such synthesis across a broader range. Furthermore, since digital and AI technologies constantly evolve, so do the requirements for competencies. Future research, therefore, will increasingly focus on integrated competency frameworks and long-term professional learning models for sustainable technology-based VET music education.

## **Conflict of Interest**

The authors stated that they have no interest conflicts relating to this research.

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