

# DIGITAL TECHNOLOGIES IN THE FORMATION OF COMMUNICATIVE AND METHODOLOGICAL COMPETENCE OF FUTURE VOCAL TEACHERS: A CONCEPTUAL FRAMEWORK FOR HIGHER ART EDUCATION

**Yaroslav M. Yotka**

Department of Vocal and Choral Mastery  
Faculty of Pedagogy, Psychology, Social Work and Arts  
Nizhyn Mykola Gogol State University  
Nizhyn, Ukraine

ORCID iD: 0000-0002-6885-6687

[yotka.yaroslav@ndu.edu.ua](mailto:yotka.yaroslav@ndu.edu.ua)

## **Abstract.**

*Digital technologies are becoming embedded in higher music education, yet their pedagogical value in vocal teacher preparation depends on how they are integrated into professional competence rather than on technological novelty itself. This conceptual study develops a framework for the formation of communicative and methodological competence of future vocal teachers in digitally enriched higher art education. The study uses structured conceptual analysis of research on vocal pedagogy, digital and AI-supported music education, teacher digital competence, and human-centred AI guidance. It distinguishes communicative competence as a combination of cognitive, verbal, non-verbal, emotional-dialogic and digital interaction capacities, and methodological competence as a combination of theoretical, procedural, diagnostic, reflective, technological and ethical capacities. Recent evidence suggests that digital tools can support feedback, reflection, practice design and teacher technological-pedagogical knowledge, while not consistently outperforming conventional instruction in musical performance outcomes. On this basis, the article proposes a six-block conceptual model linking professional aims, pedagogical principles, competence content, digitally mediated practice, reflective assessment and governance conditions. The model treats AI literacy, data stewardship, equitable access, vocal health and preservation of teacher judgement as conditions of responsible digitalisation. The contribution lies in integrating communication, methodology and digital governance into one framework for pre-service vocal teacher education. The model is conceptual and requires empirical validation through competence rubrics, longitudinal observation and controlled comparison of digitally supported and conventional training practices.*

**Keywords:** vocal pedagogy; teacher competence; digital music education; artificial intelligence; reflective practice; higher art education.

## **1. INTRODUCTION**

Digital transformation has become a structural feature of higher education rather than a temporary response to emergency remote teaching. In music and art education, however, the consequences of digitalisation are unusually complex because learning depends not only on access to information but also on embodied demonstration, auditory discrimination, artistic interpretation, interpersonal trust and repeated guided practice. Vocal pedagogy is especially sensitive to this tension. The voice is an internal instrument whose functioning cannot be observed directly by the learner, while many aspects of singing are experienced through

bodily sensation, acoustic feedback and teacher-guided interpretation. Digital technologies can broaden the means through which these processes are represented and discussed, but they can also encourage excessive visualisation, fragmented feedback or unwarranted confidence in automated analysis.

The professional preparation of future vocal teachers therefore requires more than the acquisition of isolated digital skills. A teacher must be able to decide when a digital tool serves a vocal objective, how its output should be interpreted, what information should remain under human judgement, and how technology changes the communicative relationship between teacher and student. In this context, communicative competence concerns the teacher's capacity to establish pedagogically and artistically meaningful interaction, while methodological competence concerns the capacity to design, diagnose, adapt, assess and improve the learning process. Digital competence intersects with both: it changes the media through which communication occurs and expands the repertoire of methodological actions available to the teacher.

Recent scholarship provides growing evidence for the educational relevance of digital and AI-supported music tools. Systematic reviews identify personalised practice, timely feedback, interactive learning and digital materials as recurrent affordances of AI in music education (Zhang et al., 2024; Wang et al., 2025). Research focused on sight-singing and aural training similarly reports benefits from adaptive and interactive technologies, while noting continuing problems of access, teacher preparation and algorithmic transparency (Chen & Lin, 2026). In vocal education specifically, spectrum-based approaches have been discussed as a way of making selected acoustic features more visible to learners (Du & Idris, 2025), and an experimental study of pre-service teachers found that AI-assisted feedback combined with audio comparison and reflective journaling improved metacognitive outcomes, although it did not demonstrate a superior group-by-time effect for singing performance itself (Li et al., 2025). This distinction is important: current evidence supports the pedagogical usefulness of digital feedback and reflection more clearly than it supports claims that AI can replace expert vocal instruction.

At the same time, research on pre-service music teachers shows that competence development depends on pedagogical design rather than on access to generative AI alone. Li, Chai, and Wang (2025) found that a structured design-with-AI intervention enhanced pre-service music teachers' self-perceived GenAI-related technological pedagogical content knowledge (TPACK) and encouraged critical evaluation of generated outputs. At the policy level, UNESCO's AI Competency Framework for Teachers emphasises a human-centred mindset, AI ethics, AI foundations, AI pedagogy and professional learning, and explicitly connects teacher competence with human agency, sustainability and enabling institutional conditions (Miao & Cukurova, 2024). These findings suggest that digital competence should not be treated as an additional software skill but as a component of professional judgement.

The remaining gap lies in the connection between this emerging digital evidence and the specific professional architecture of vocal teacher education. Existing studies often analyse particular technologies, performance outcomes or general music-teacher digital competence. Less attention is given to how digital practices simultaneously reshape two core capacities of a future vocal teacher: the ability to communicate complex embodied vocal

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phenomena and the ability to make methodologically justified pedagogical decisions. The present article addresses this gap by developing a conceptual framework in which digital technologies function as mediators of communication, diagnosis, reflection and learning design rather than as autonomous determinants of educational quality.

The question also has a sustainable-governance dimension. Higher education institutions must decide which tools are approved, how student voice recordings are stored and reused, how unequal access to equipment is addressed, how teachers are trained, and how responsibility is allocated when AI-generated feedback is inaccurate. Sustainable digitalisation in art education therefore means the capacity to maintain pedagogical quality, human agency, equity and accountability while technologies change. In this sense, institutional governance is not external to competence formation: it defines the conditions under which digital competence can be exercised responsibly.

## **2. RESEARCH AIM, QUESTIONS AND METHOD**

The aim of the article is to develop a conceptually grounded model for forming the communicative and methodological competence of future vocal teachers through digital technologies in higher art education. The study addresses four questions: (1) Which components of communicative and methodological competence are specifically affected by digitalisation? (2) Which digitally mediated practices have a plausible or evidence-supported role in competence formation? (3) What conditions are required to prevent technology from displacing artistic judgement, vocal health and teacher responsibility? and (4) How can these elements be integrated into a coherent framework suitable for curriculum design and subsequent empirical testing?

Methodologically, the article uses structured conceptual analysis and pedagogical modelling. It draws on four bodies of material: scholarship on communicative and methodological competence in vocal and music teacher education; peer-reviewed studies and systematic reviews on digital and AI-supported music learning; empirical studies of feedback, reflection and teacher AI/TPACK development; and authoritative guidance on human-centred and ethical AI in education. The review is integrative rather than systematic: it does not claim exhaustive database coverage, calculate pooled effects or apply PRISMA screening procedures. Sources are used to clarify concepts, identify convergent pedagogical mechanisms and delimit claims that cannot yet be supported by evidence.

The analytical procedure consisted of four steps. First, the professional functions of a vocal teacher were grouped around communication and methodological decision-making. Second, digital practices were mapped to those functions according to their educational role rather than their brand or technical novelty. Third, the potential benefits of each practice were paired with limiting conditions such as validity of feedback, privacy, access and preservation of human judgement. Fourth, these relationships were synthesised into a conceptual model and an implementation matrix. No survey, experiment, interview or observation was conducted for the present study; therefore, statements about competence development are theoretical propositions informed by prior research, not original measured outcomes.

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### **3. COMPETENCE ARCHITECTURE OF THE FUTURE VOCAL TEACHER**

#### **3.1. COMMUNICATIVE COMPETENCE IN DIGITALLY MEDIATED VOCAL PEDAGOGY**

Communicative competence in vocal pedagogy may be defined as the integrated capacity to organise clear, ethical, emotionally sensitive and artistically meaningful interaction with a learner. Its specificity follows from the nature of vocal instruction. Teachers frequently need to translate invisible physiological and acoustic processes into language, demonstration, metaphor, gesture and sound. Explanations of breath coordination, resonance, registration, diction or timbral balance cannot be reduced to terminology alone; they require attention to what the learner hears, feels and understands.

For conceptual purposes, five interrelated components can be distinguished. The cognitive-verbal component includes specialised vocabulary and the ability to explain it in accessible form. The demonstrative-non-verbal component includes vocal modelling, gesture, posture and visual cues. The emotional-dialogic component includes empathy, psychological safety, questioning and listening to the student's subjective sensations. The artistic-interpretive component concerns communication of style, phrasing, character and meaning. The digital-communicative component concerns asynchronous comments, annotated recordings, online lesson etiquette, multimodal explanations and the critical use of AI-mediated dialogue.

Digitalisation changes communicative competence by increasing the number of representational channels available to the teacher. A student may receive an audio comparison, a marked score, a short video demonstration, a spectrogram, written comments and reflective prompts. Such multimodality can make feedback more persistent and reviewable. Yet more channels do not automatically produce better communication. When feedback is excessively technical, contradictory or decontextualised, the learner may attend to visible metrics rather than musical intention or bodily sensation. Communicative competence therefore includes the ability to select the minimum useful representation and to translate digital evidence back into an intelligible vocal task.

#### **3.2. METHODOLOGICAL COMPETENCE AS PROFESSIONAL DECISION-MAKING**

Methodological competence is the capacity to design, conduct, evaluate and improve vocal learning through reasoned pedagogical decisions. It transforms teaching from the imitation of inherited practices into reflective professional action. The future vocal teacher must be able to formulate objectives, select repertoire, construct exercises, sequence tasks, distinguish technical from musical or psychological difficulties, monitor progress and adapt teaching to the learner's vocal development.

Six components are especially relevant. The theoretical component covers voice science, acoustics, repertoire, style and pedagogy. The procedural-design component concerns lesson planning and sequencing. The diagnostic component concerns identification of the most plausible source of a difficulty and the limits of the teacher's competence. The adaptive component concerns modifying tasks for individual voices and learning conditions. The reflective-assessment component concerns evidence-based evaluation of both student pro-

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gress and the teacher's own choices. The technological-ethical component concerns selecting digital tools, interpreting their outputs, protecting learner data and recognising when a technological intervention is methodologically unnecessary.

Digital tools can support methodological competence only when the student teacher must justify their use. Creating a vocalise in notation software is methodologically meaningful when range, tessitura, vowel, rhythm and progression of difficulty are linked to a defined learning objective. Analysing a recording is meaningful when the observed acoustic feature is connected cautiously to audible performance and a pedagogical response. Asking a generative AI system to produce lesson ideas is meaningful when the student evaluates, rejects and revises those ideas using domain knowledge. The methodological task is therefore not tool operation but reasoned selection, interpretation and adaptation.

### **3.3. DIGITAL COMPETENCE AS A CROSS-CUTTING PROFESSIONAL CONDITION**

The framework proposed here does not treat digital competence as a third independent competence alongside communication and methodology. Instead, it functions as a cross-cutting condition that modifies both. This position is consistent with contemporary teacher-AI frameworks that place AI use within pedagogy, ethics, professional learning and human-centred decision-making rather than within a narrow category of software proficiency (Miao & Cukurova, 2024). For future vocal teachers, digital competence comprises tool literacy, AI literacy, data literacy, critical evaluation of automated output, online communication, copyright awareness, privacy and basic information-security behaviour. Its quality is demonstrated not by the number of platforms a student can use but by the quality of professional decisions made with and about those platforms.

## **4. EVIDENCE-INFORMED DIGITAL PRACTICES AND THEIR PEDAGOGICAL BOUNDARIES**

A useful way to organise digital technologies in vocal teacher education is by educational function. This avoids rapid obsolescence caused by listing particular commercial products and focuses instead on what the technology enables the learner or teacher to do. Systematic reviews in music education distinguish practice, theory/literacy, creativity and feedback functions, while also warning that the evidence base remains heterogeneous and methodologically uneven (Liu et al., 2025; Zhang et al., 2024). For vocal teacher preparation, six functional groups are especially relevant: notation and resource design; recording and video feedback; acoustic visualisation; generative AI and conversational support; blended learning and digital portfolios; and collaborative/creative media production.

**Table 1. Functional classification of digital practices in pre-service vocal teacher education**

| Functional group                              | Typical uses                                                                 | Potential competence contribution                                                                  | Pedagogical boundary / condition                                                                                                        |
|-----------------------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Notation and resource design                  | Notation software, digital scores, accompaniment and transposition tools     | Designing exercises and explaining musical tasks; adapting repertoire to range and learning goals  | The student teacher must justify pedagogical purpose, range, tessitura and progression; notation should not substitute for listening.   |
| Recording and video feedback                  | Audio/video capture, annotation, comparison and portfolio tools              | Persistent feedback, self-observation, peer dialogue and reflective assessment                     | Recording can increase self-consciousness; assessment criteria and psychologically safe feedback are required.                          |
| Acoustic visualisation                        | Pitch tracking, spectrum and other voice-analysis tools                      | Supporting diagnostic questioning and multimodal explanation of selected acoustic features         | Visual metrics are proxies, not artistic verdicts; inaccurate interpretation can encourage unhealthy or mechanically optimised singing. |
| Generative AI                                 | LLM-based dialogue, planning support, prompts, rubrics and resource drafting | Supporting reflective questions, alternative lesson ideas and critical pedagogical design          | Outputs require verification; teacher judgement, copyright, privacy and bias must remain explicit learning objectives.                  |
| Blended learning and portfolios               | LMS, video conferencing, e-portfolios and reflective journals                | Organising independent preparation, asynchronous communication and longitudinal evidence of growth | Unequal access, platform overload and poor audio quality can reduce educational value.                                                  |
| Collaborative and creative digital production | Shared media, simple editing, presentation and content-creation tools        | Developing communication, presentation, creativity and public-facing professional literacy         | Production quality should remain subordinate to musical and pedagogical aims; permissions are required for identifiable recordings.     |

#### 4.1. FEEDBACK, REFLECTION AND METACOGNITION

Feedback and reflection provide the strongest conceptual bridge between communicative and methodological competence. Digital recording allows the learner to revisit an event that would otherwise disappear after performance. Annotation and comparison can make feedback more specific, while reflective journals can require the student to explain what changed, why it changed and what should happen next. Importantly, recent experimental evidence in vocal training supports a cautious rather than triumphalist interpretation. Li et al. (2025) found that AI-assisted feedback, audio comparison and reflective writing produced stronger metacognitive development, but the intervention did not show a superior interaction effect for singing performance. This suggests that digitally supported reflection may strengthen the learner's capacity to monitor and regulate practice even when measurable performance advantages are less clear.

For teacher education, this distinction is productive. A future vocal teacher should not be trained to believe that a tool 'improves singing' by itself. The student should instead learn to use recordings and automated feedback as evidence for professional reasoning: identify a problem, compare sources of evidence, formulate a hypothesis, select an intervention and evaluate the result. Such a cycle directly links communicative feedback to methodological decision-making.

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## **4.2. GENERATIVE AI AND THE FORMATION OF PEDAGOGICAL JUDGEMENT**

Generative AI deserves separate treatment because it produces language, suggestions and instructional materials in a form that resembles professional reasoning. Its educational risk is therefore epistemic as well as technical: fluent output may conceal weak domain understanding. Research with pre-service music teachers indicates that structured design tasks can turn this weakness into a learning opportunity when students are required to critique and revise AI-generated materials rather than accept them as finished products (Li, Chai, & Wang, 2025). In such tasks, competence is demonstrated through evaluation: Is the suggested exercise vocally safe? Is the repertoire appropriate? Does the explanation use terminology accurately? Is the feedback artistically meaningful? What evidence supports the recommendation?

A human-centred approach also requires explicit limits. UNESCO guidance emphasises human agency, ethical validation, data privacy and pedagogical appropriateness in educational AI (Miao & Holmes, 2023; Miao & Cukurova, 2024). In vocal education this means that generative AI should not be positioned as an autonomous assessor of artistic quality, a substitute for specialist diagnosis or a decision-maker about vocal health. Its legitimate educational roles are narrower: generating alternatives, supporting reflection, drafting low-stakes resources and creating material that students can critically evaluate.

## **4.3. ACOUSTIC ANALYSIS AND EMBODIED KNOWLEDGE**

Spectrum and pitch-analysis tools can help students connect listening with selected measurable properties of sound. Du and Idris (2025) identify spectrum-based pedagogy as a developing approach in vocal music education, and Zhang (2026) reports the use of mobile and wearable technologies in vocal training. These studies expand the available evidence base, but the pedagogical interpretation remains crucial. Acoustic representations do not display ‘correct singing’ in a complete sense. They isolate measurable features from a complex embodied and artistic event. A future teacher should therefore be taught to triangulate: listen, observe, ask about bodily sensation, consider musical context and use visual data only where it answers a defined pedagogical question.

## **5. CONCEPTUAL MODEL OF COMPETENCE FORMATION**

On the basis of the preceding analysis, the article proposes a six-block model of competence formation. The model is cyclical rather than linear: practice generates evidence, evidence supports reflection, reflection modifies methodological decisions, and those decisions reshape communication in the next learning episode. Digital technologies enter the cycle only where they perform a defined educational function. Governance conditions surround the cycle because access, privacy, institutional rules and teacher capacity determine whether the same technology becomes pedagogically useful or problematic.

**Table 2. Conceptual model for communicative and methodological competence formation through digital technologies**

| Block                          | Core content                                                                                                                 | Observable educational result                                                                      |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| 1. Target block                | Formation of communicative clarity, methodological judgement and responsible digital-pedagogical readiness                   | Students can explain why technology is used and identify what should remain under human judgement. |
| 2. Principle block             | Student-centredness, artistic integrity, vocal health, human agency, evidence-informed practice, equity and ethics           | Digital choices are evaluated against pedagogical and human criteria, not novelty.                 |
| 3. Content block               | Vocal pedagogy, methodology, communication, assessment, digital/AI literacy and data stewardship                             | Professional knowledge is integrated across artistic, pedagogical and technological domains.       |
| 4. Practice block              | Exercise design, recording analysis, video feedback, AI critique, online teaching episodes, peer assessment and e-portfolios | Students practise professional decisions in authentic or simulated pedagogical situations.         |
| 5. Reflective-assessment block | Rubrics, self-explanation, peer/teacher feedback and portfolio evidence                                                      | Students make their reasoning visible and revise decisions on the basis of evidence.               |
| 6. Governance block            | Approved tools, access, consent, data retention, staff support, escalation of health/safeguarding concerns                   | Technology use remains accountable, equitable and sustainable at institutional level.              |

The novelty of the model lies not in introducing an additional list of digital tools, but in relocating technology within the competence cycle. The same platform can contribute to competence or weaken it depending on the task. For example, generative AI used to produce a ready-made lesson plan with no evaluation may reduce methodological reasoning, whereas the same system used to generate three contrasting plans that students must diagnose, critique and redesign can make reasoning explicit. Likewise, a spectrogram used as an aesthetic score can distort vocal learning, while a spectrogram used to test a carefully formulated acoustic hypothesis can strengthen diagnostic thinking.

## 6. GOVERNANCE CONDITIONS FOR SUSTAINABLE DIGITAL VOCAL TEACHER EDUCATION

The institutional dimension is essential because individual teacher competence cannot compensate indefinitely for poor governance. Sustainable digitalisation requires arrangements that preserve educational continuity, equity, accountability and human agency as tools and vendors change. This is particularly important in art education, where commercially available applications may be adopted informally before institutions establish rules for recordings, AI services or student consent.

### 6.1. HUMAN AGENCY AND PROFESSIONAL RESPONSIBILITY

The first governance principle is that technology should extend, not transfer, professional responsibility. The teacher remains accountable for pedagogical decisions, and students should learn that automated output is advisory evidence rather than authority. This principle aligns with UNESCO's teacher AI competency framework, which places a human-centred mindset and ethics before technical application (Miao & Cukurova, 2024). In practical terms, programmes should identify decisions that require human review: repertoire selection where vocal health is implicated, feedback on possible dysfunction, high-stakes assessment, safeguarding issues and any decision based on sensitive personal information.

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## **6.2. VOICE RECORDINGS, PRIVACY AND DATA STEWARDSHIP**

Vocal teacher education routinely generates identifiable audio and video recordings. Once recordings are uploaded to cloud platforms, AI services or shared portfolios, their educational use becomes a data-stewardship issue. Institutions should define who may record, the purpose of recording, where files are stored, who may access them, how long they are retained and whether they may be reused for teaching or AI-supported analysis. Consent should be meaningful and linked to a specific educational purpose. Student teachers should also learn to minimise data disclosure: a recording or document should not be uploaded to an external AI service merely because doing so is technically possible.

## **6.3. EQUITY, ACCESS AND THE DIGITAL DIVIDE**

The second sustainability condition is equitable access. High-quality microphones, stable broadband, current devices and paid software are unevenly distributed. Systematic reviews in music education repeatedly identify access and teacher preparation as constraints on digital implementation (Chen & Lin, 2026; Liu et al., 2025). Consequently, programmes should avoid designing mandatory learning outcomes around tools that only some students can obtain. Institutional licences, shared equipment, low-bandwidth alternatives and equivalent non-digital routes are governance mechanisms that protect equal participation.

## **6.4. CAPACITY BUILDING AND TOOL LIFECYCLE**

A third condition is institutional capacity. Digital sustainability is weakened when a course depends on one enthusiastic teacher or one rapidly changing platform. Teacher educators require continuing professional development in AI literacy, data protection and domain-specific digital pedagogy. Tools should be reviewed periodically for educational relevance, accessibility, data practices and continuity. This shifts the question from ,Which app should we use?' to ,Which educational function must the programme support, and what is the safest and most sustainable way to support it?' Such governance reduces technological overload and makes curricula more resilient to platform change.

## **7. CURRICULUM IMPLEMENTATION AND ASSESSMENT**

The conceptual model can be implemented without creating a separate technology course. A stronger approach is to embed digitally mediated tasks within existing vocal pedagogy, methodology and teaching-practice modules. The developmental sequence should move from controlled use to critical design and, finally, to justified independent selection. This mirrors the progression from acquiring foundational AI competence to deepening and creating pedagogical applications described in international teacher-competency guidance (Miao & Cukurova, 2024).

**Table 3. Suggested curriculum sequence and assessment evidence**

| Stage                                       | Learning activity                                                                         | Competence focus                                                                                   | Assessment evidence                                            |
|---------------------------------------------|-------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
| Stage 1: Guided literacy                    | Introduction to recording, notation, LMS and AI principles; privacy and ethical scenarios | Identify tool function; distinguish data from interpretation; recognise unsafe or unnecessary uses | Short critique; terminology quiz; privacy/ethics case response |
| Stage 2: Structured application             | Design a vocal exercise; annotate a recording; compare human and AI feedback              | Connect a digital action to a vocal objective; explain limitations and adaptations                 | Rubric-scored teaching artefact plus reflective rationale      |
| Stage 3: Pedagogical design                 | Plan a blended teaching episode using selected tools and alternatives                     | Integrate communication, methodology and access considerations                                     | Microteaching, peer review and revision                        |
| Stage 4: Reflective practice                | Build an evidence-based e-portfolio across several teaching episodes                      | Evaluate changes in teaching decisions and feedback quality over time                              | Portfolio defence and self-assessment                          |
| Stage 5: Independent professional judgement | Select or reject digital tools for a complex learner scenario                             | Demonstrate justified, ethical and sustainable decision-making                                     | Case-based oral defence using a competence rubric              |

Assessment should prioritise reasoning rather than the polished appearance of digital products. A student who produces an attractive video but cannot explain the pedagogical purpose, limitations or data implications has not demonstrated methodological competence. Conversely, a student who rejects an AI tool because the feedback is unreliable for the specific vocal problem may demonstrate a higher level of digital-pedagogical judgement than a student who uses the tool extensively. Suggested rubric dimensions include clarity of pedagogical objective, quality of vocal-methodological reasoning, communication and feedback, critical interpretation of digital evidence, ethical/data awareness, accessibility and reflective revision.

## 8. CHALLENGES, LIMITATIONS AND RESEARCH AGENDA

Four challenges remain central. First, technological overload can fragment attention and shift lesson time from listening and embodied learning to interface management. Second, algorithmic and measurement limitations can create false precision, particularly when complex artistic outcomes are reduced to pitch, frequency or automated text feedback. Third, unequal access can reproduce rather than reduce educational inequality. Fourth, AI and cloud-based services can externalise data and decision processes beyond the direct control of the teacher or institution. These challenges do not justify rejecting digital technologies, but they require selective adoption and explicit governance.

The present study also has clear limitations. It is conceptual and does not test the proposed model with a cohort of future vocal teachers. The literature base is interdisciplinary and heterogeneous, and findings from general music education, elementary music or teacher-AI studies cannot be transferred automatically to one-to-one vocal pedagogy. Several recent studies come from particular national and institutional contexts, so cultural and curricular transfer requires caution. The article therefore avoids quantitative claims about the magnitude of competence improvement and treats the proposed relationships as hypotheses for empirical validation.

Future research should proceed in three directions. The first is measurement: validated

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rubrics are needed for communicative, methodological and digital-pedagogical competence in vocal teaching. The second is comparative intervention research: studies should distinguish outcomes such as metacognition, teaching judgement, vocal performance, learner autonomy and feedback quality rather than assuming that all improve together. The third is longitudinal and governance-oriented research: it should examine whether digitally enriched training changes graduates' actual teaching practices, how institutional rules affect adoption, and whether access, privacy and technology costs create differential outcomes across student groups.

## 9. CONCLUSIONS

Digital technologies can make a substantive contribution to the professional preparation of future vocal teachers, but their value is conditional. The central educational problem is not the acquisition of individual applications; it is the formation of professional judgement capable of integrating artistic goals, vocal health, communication, methodology and digital evidence. Communicative competence enables the future teacher to explain, demonstrate, listen, give feedback and sustain artistic dialogue across face-to-face and digital environments. Methodological competence enables the teacher to design, diagnose, adapt, assess and revise teaching. Digital competence modifies both by adding new media, new forms of evidence and new ethical responsibilities.

The conceptual model developed in this article integrates these capacities through six blocks: target, principles, content, practice, reflective assessment and governance. The model positions recording, acoustic analysis, generative AI, digital portfolios and blended-learning environments as pedagogical mediators rather than autonomous sources of educational quality. Recent empirical studies support this restrained interpretation: digitally and AI-supported practices can strengthen reflection, metacognition and teacher technological-pedagogical knowledge, while evidence for superior musical performance outcomes is more context-dependent. The appropriate educational response is therefore neither technological enthusiasm nor rejection, but structured critical use.

The scientific contribution of the article is the integration of communicative and methodological competence with digital-pedagogical judgement and institutional governance in a single framework specific to vocal teacher education. Its practical significance lies in a curriculum logic that can be implemented through existing pedagogy and teaching-practice modules and assessed through observable reasoning, feedback, design and reflective evidence. Sustainable digitalisation of higher art education requires more than competent individuals: institutions must also provide equitable access, data stewardship, approved and reviewable tools, teacher development and clear preservation of human responsibility. Empirical validation of the model is the next necessary step.

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## CONFLICTS OF INTEREST

The author declares no conflicts of interest.

## DATA AVAILABILITY

No original datasets were generated or analysed in this conceptual study. The article is based on published scholarly and policy sources cited in the reference list.

## ETHICS STATEMENT

The study did not involve human participants, personal data collection or experimental procedures; institutional ethics approval was therefore not required for the present conceptual analysis.

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