INTEGRATING DIGITAL PEDAGOGY INTO TRADITIONAL MUSIC EDUCATION

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Abstract

Traditional approaches to music pedagogy, rooted in the work of eminent twentieth-century educators (e.g., Kodály, Orff), emphasize the cultivation of musical sensitivity through singing, solmization, rhythmic exercises, and improvisation. These practices remain central in

contemporary music education. At the same time, digital pedagogy introduces a new dimension, facilitating the design, delivery, and evaluation of instruction through interactive platforms, learning management tools, and virtual learning spaces. This study focuses on the pedagogical integration of artificial intelligence (AI)-based software within the context of general music education. The focus is on the Solfy program, designed both as an interactive classroom tool and as support for independent home practice. Its distinctive feature is the AI-driven voice recognition system that delivers immediate, personalized feedback, enabling differentiated development of vocal skills. The study shows that Solfy can effectively complement traditional pedagogical methods at the pre-vocational stage. By integrating AI-based tools into established practices, music education can become more efficient, accessible, and reflective, for example, in areas such as intonation accuracy, tonal stability, and vocal confidence. Immediate feedback, error detection, and reward mechanisms (e.g., orchestral accompaniment) can foster consistent practice, reduce performance anxiety, and enhance learner autonomy by encouraging independent, goal-oriented learning strategies.

Keywords: Environmental noise; MATLAB; tensor data; singular value decomposition; smart city monitoring

Discipline: Environmental Engineering

Absztrakt

A DIGITÁLIS PEDAGÓGIA INTEGRÁLÁSA
A HAGYOMÁNYOS ZENEOKTATÁSBA

A zenepedagógia hagyományos megközelítései, amelyek kiemelkedő huszadik századi pedagógusok (pl. Kodály, Orff) munkásságában gyökereznek, a zenei érzékenység fejlesztését hangsúlyozzák éneklés, szolmizáció, ritmikus gyakorlatok és improvizáció révén. Ezek a gyakorlatok továbbra is központi szerepet játszanak a kortárs zenei nevelésben. Ugyanakkor a digitális pedagógia új dimenziót vezet be, elősegítve az oktatás tervezését, lebonyolítását és értékelését interaktív platformok, tanulásmenedzsment eszközök és virtuális tanulási terek segítségével. Ez a tanulmány a mesterséges intelligencia (MI) alapú szoftverek pedagógiai integrációjára összpontosít az általános zenei nevelés kontextusában. A hangsúly a Solfy programon van, amelyet interaktív tantermi eszközként és az önálló otthoni gyakorlás támogatására is terveztek. Megkülönböztető jellemzője a mesterséges intelligencia által vezérelt hangfelismerő rendszer, amely azonnali, személyre szabott visszajelzést ad, lehetővé téve a vokális készségek differenciált fejlesztését. A tanulmány kimutatja, hogy a Solfy hatékonyan kiegészítheti a hagyományos pedagógiai módszereket a szakmai előkészítő szakaszban. A mesterséges intelligencia alapú eszközök bevett gyakorlatokba való integrálásával a zenei nevelés hatékonyabbá, hozzáférhetőbbé és reflektívebbé válhat például olyan területeken, mint az

intonációs pontosság, a hangszínstabilitás és az énekhanggal kapcsolatos magabiztosság. Az azonnali visszajelzés, a hibaészlelés és a jutalmazási mechanizmusok (pl. zenekari kíséret) elősegíthetik a következetes gyakorlást, csökkenthetik a teljesítmény miatti szorongást és fokozhatják a tanuló autonómiáját azáltal, hogy ösztönzik a független, célorientált tanulási stratégiákat.

Kulcsszavak: környezeti zaj; MATLAB; tenzoradatok; szinguláris érték-felbontás; okosváros-monitorozás

Diszciplína: környezetmérnöki tudomány

Digital pedagogy refers to the processes of designing, implementing, and evaluating learning supported by digital technologies. It encompasses educational platforms, interactive resources, and intelligent applications capable of providing immediate feedback and adapting tasks to learners' individual needs (European Commission, 2021; UNESCO, 2023; Zhang & Zhang, 2024). In recent years, artificial intelligence (AI) has emerged as a particularly promising tool for the personalization of learning experiences, contributing simultaneously to the development of musical and digital competences (Li et al., 2025; Han, 2025).

Traditional music education—grounded in vocal training, solfège, improvisation, and instrumental performance, and shaped by paradigms such as the Kodály and Orff approaches—remains an essential methodological reference point. The introduction of digital technologies does not displace these practices but rather extends and amplifies them, creating a productive dialogue between tradition and innovation. In this context, technology does not substitute the teacher; instead, it strengthens the teacher's role as mediator of the musical experience.

Current scholarship identifies three major directions for applying AI in music education. The first concerns feedback and self-monitoring, where applications such as Solfy or SmartMusic enable immediate correction of intonation and rhythm, fostering autonomy and efficiency in individual practice (Li et al., 2025; Nichols, 2014). The second involves AI-assisted creativity and expressivity, through generative tools that support adolescents' creative activity and reduce performance-related anxiety (Hu et al., 2025; Cheng, 2025). The third focuses on algorithmic models for teaching and assessment, developed mainly in higher education, which employ neural networks or large language model–based agents to support music theory learning and the analysis of vocal performance (Han, 2025; Jin et al., 2025; Wei et al., 2022).

In the Romanian context, Pop-Sârb (2021) demonstrated that integrating digital solutions and AI-based applications can provide valuable pedagogical support for renewing

school music education. At the same time, Popean (2022) warned against the risk of absolutizing technology and losing the authentic artistic dimension in the absence of critical reflection. More recent contributions emphasize the role of singing and (self-)evaluation in broad-based music literacy, as evidenced by Muntean, Weidenfeld, and Koren (2022), as well as in research presented at ISME (Muntean & Koren, 2022). In this regard, applications such as Solfy operationalize the principles of music literacy through singing and self-assessment in an accessible format that combines progress monitoring, individualized development, and reflective feedback.

International analyses confirm that AI has the potential to accelerate learning, personalize educational trajectories, and foster reflective dimensions of music training—provided that it is implemented responsibly and supported by ongoing teacher development (Merchán Sánchez-Jara et al., 2024; O'Leary, 2025). Thus, the integration of digital pedagogy and AI tools should be understood not simply as a technological innovation but as a methodological transformation, one in which educational traditions are interwoven with emerging practices, preparing learners for music education attuned to the realities of the twenty-first century.

Against this conceptual and empirical background, the present study advances the discussion by examining the use of Solfy at the pre-vocational level—an educational stage less frequently explored in the international literature—thereby contributing new insights into how AI can support early vocal development while complementing traditional pedagogical methods.

Unlike previous studies that primarily examined AI integration at university or advanced levels, the present study focuses on the pre-vocational stage, contributing new empirical insights into how AI can support early vocal development.

Demonstration of using Solfy in a classic musical development

The example below demonstrates the possibility of integrating the Solfy (an AI-based digital tool) into individual vocal training. This case shows not only the participant's technical progress but also the motivational and self-reflective dynamics associated with learning by the example of a 14-year-old student preparing for admission to a vocational high school with a music specialization. Ethical considerations were carefully observed: informed consent was obtained from the student's parents, and the participant voluntarily agreed to take part in the diagnostics and development. The research was conducted in line with institutional ethical guidelines for studies involving minors. Written parental consent and participant assent were obtained prior to data collection, and all data were anonymized.

At baseline, her competence level was characterized by unstable intonation, limited breath control, and reduced experience in repertoire performance.

The intervention extended over three months (March–May 2024) and was struc-

tured into two successive stages. The first stage involved established traditional methods, including breathing exercises, intonation and solfège training through the Kodály method, and rhythmic activities inspired by Dalcroze eurhythmics. The second stage introduced the Solfy application, an AI-based educational tool that provides instant feedback on intonation and rhythm, monitors error typologies, and offers motivational reinforcement through orchestral accompaniment.

Data were collected using a combination of complementary methods:

- direct observation of practice sessions;
- audio recordings taken at the beginning and end of the intervention;
- Solfy-generated reports documenting the frequency and typology of errors;
- the participant's reflective journal, where she recorded perceptions of progress and motivation.

The analysis combined qualitative and quantitative procedures. Vocal performances were comparatively assessed at baseline and post-intervention; intonation errors and tonal stability were quantified using Solfy's analytical reports; and information derived from observation and journaling was triangulated to strengthen interpretive validity. Pitch stability was assessed through Solfy-generated feedback. No external measurement tools (e.g., acoustic analysis software) were employed, and results are presented as estimates. This mixed-method approach provided a comprehensive view of the effects generated by integrating the application into the learning process.

The analysis of the collected data revealed a marked and consistent improvement in the participant's vocal performance across the intervention. During the initial stage, which relied exclusively on traditional methods, progress was modest: breath control improved slightly, and isolated sounds were intoned more accurately. However, persistent difficulties with tonal stability and fluent repertoire performance highlighted the limitations of training based solely on conventional techniques.

By contrast, the introduction of the Solfy application represented a turning point in the learning trajectory. Instant visual and auditory feedback enabled rapid error correction, while application-generated reports provided an objective basis for monitoring progress. As shown in Figure 1, the percentage of correctly intoned notes increased from an estimated 30% in Lesson 1 (Recording #35) to 100% in Lesson 12 (Recording #558), with incorrect and approximate notes eliminated. This progression demonstrates a substantial gain in vocal-technical accuracy. Percentages shown in Figure 1 are derived from Solfy's visual feedback reports and should be understood as estimates of pitch accuracy, rather than precise acoustic measurements.

The Solfy performance scores further corroborate these results. As illustrated in Figure 2, repeated attempts during early May (Recordings #241–388) consistently scored 0%, reflecting intonational instability. How-

Figure 1. Progression of Pitch Accuracy in Solfy. Source: Authors

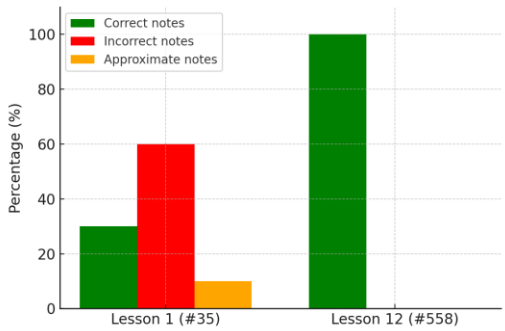
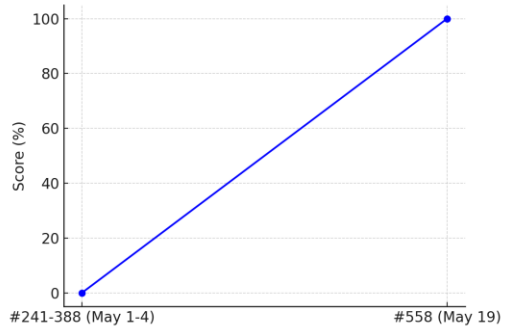


Figure 2. Progression of Solfy Performance Scores. Source: Authors



ever, by May 19 (Recording #558), the participant achieved a score of 100%, indicating complete alignment with pitch targets. This sharp improvement suggests that iterative practice, reinforced by instant feedback, supported rapid consolidation of vocal control.

Beyond technical accuracy, the intervention fostered learner autonomy and self-regulation, directly addressing the evaluation of self-monitoring and feedback impact. The possibility of repeating exercises until mastery, combined with visual progress tracking and orchestral rewards, created a strong sense of control over personal development. In her reflective journal, the participant described Solfy practice as "clearer, faster, and more motivating," a finding consistent with recent studies emphasizing AI's role in supporting self-regulation and reducing performance anxiety (Li et al., 2025; Zhang & Zhang, 2024). The results also confirm that AI complements rather than replaces the teacher's role - so this method, corresponding to the needs of pedagogical transferability. The intervention demonstrated that traditional methods such as breathing and solfège remain essential but are amplified by instant feedback and self-monitoring. In this respect, Solfy acted as a "pedagogical mediator," enabling independent practice without undermining corrective rigor. This conclusion echoes Pop-Sârb's (2021) emphasis on the value of digital technologies as pedagogical support and resonates with Popean's (2022) caution against over-reliance on technology at the expense of artistic authenticity.

Similar to recent studies and global trends, the present case shows that AI platforms can accelerate learning (Merchán Sánchez-Jara et al., 2024), stimulate autonomy (O'Leary, 2025), and democratize music literacy through accessible interactive resources (Muntean, Weidenfeld, & Koren, 2022). Nonetheless, the experiences also highlight contextual factors—such as the learner's initial competence, selected repertoire, and teacher

readiness—that mediate effectiveness. These convergences underscore that findings from a Romanian pre-vocational context are consistent with global trends, suggesting transferability across cultural settings.

Moreover, the experiences support the view that AI tools like Solfy can function as vectors of music literacy. By combining singing with (self-)evaluation, the application extends beyond technical skill development to foster music reading and score comprehension. This aligns with ISME 2022 findings (Muntean & Koren), which demonstrated that self-singing solfège contributes to democratizing music literacy from the early years of schooling.

In summary, the experiences converge on two key directions:

• The responsible integration of AI in music education can accelerate technical progress and strengthen learner autonomy.

• The complementarity of traditional methods and digital applications provides a foundation for an integrative pedagogical model, where music literacy becomes more accessible, personalized, and reflective.

Conclusions

The AI-based Solfy application can produce positive effects on both vocal-technical progress and learner autonomy at the early stages of vocational training. Instant feedback, self-monitoring, and reward mechanisms contributed to an accelerated pace of learning and enhanced confidence in personal abilities. The experiences confirm that digital solutions do not replace traditional methods of music education but rather complement them, amplifying the teacher's role. Instead of diminishing the importance of the instructor, applications such as Solfy extend the range of pedagogical intervention and create favorable conditions for differentiated and personalized instruction. This perspective aligns with international literature emphasizing the role of AI in accelerating learning, fostering self-regulation, and democratizing music literacy (Li et al., 2025; Merchán Sánchez-Jara et al., 2024; Muntean, Weidenfeld & Koren, 2022).

The introduced example demonstrated, music literacy can be advanced by combining singing with AI-assisted (self-)evaluation, thereby opening opportunities for broader democratization of access to music literacy. AI technologies can simultaneously support the development of musical and digital competences, an aspect particularly relevant within the current European and international educational landscape.

Several directions for future development emerge from these findings. Methodologically, larger-scale studies are needed to confirm the identified tendencies and to build scalable pedagogical models. Practically, AI integration could be explored beyond vocal training, extending to instrumental accompaniment, improvisation, and AI-assisted creativity. Organizationally, the study underscores the necessity of continuous professsional development programs to prepare teachers for the responsible and effective use of digital tools. From the aspects of future research, the AI impacts on diagnostics and development in the area of music pedagógy,

and the systematic integration of AI into formal curricula can be investigated, thereby enriching classroom practice and advancing the dialogue on music education in the digital era.

Overall, the contribution of this study is to demonstrate that tradition and innovation are not mutually exclusive but can be articulated within an integrative pedagogical framework. The integration of AI applications such as Solfy offers a genuine opportunity to design music education that is more accessible, more personalized, and more reflective, attuned to the cultural realities and educational demands of the twenty-first century.

Authors' Note

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References

Solfy (website). Opened: 1.12.2025. URL: https://4solfy.com/

Cheng, L. (2025). The impact of generative AI on school music education: Challenges and recommendations. *Arts Education Policy Review*. Doi: https://doi.org/10.1080/10632913.2025.2451373

European Commission. (2021). *Digital Education Action Plan 2021–2027: Resetting education and training for the digital age*. Publications Office of the European Union. Doi: https://doi.org/10.2766/149764

Han, Y. (2025). Exploring a digital music teaching model integrated with recurrent neural networks under artificial intelligence. *Scientific Reports*, 15, 7495. Doi: https://doi.org/10.1038/s41598-025-92327-8

Hu, Z., Liu, Y., Zhang, Z., Chen, G., Yu, B. X. B., Li, J., & Cao, J. (2025). MusicScaffold: *Bridging machine efficiency and human growth in adolescent creative education through generative AI* (arXiv:2509.10327). arXiv. Opened: 1.12.2025. URL: https://arxiv.org/abs/2509.10327

Jin, L., Lin, B., Hong, M., Zhang, K., & So, H. J. (2025). *Exploring the impact of an LLM-powered teachable agent on learning gains and cognitive load in music education* (arXiv:2504.00636). arXiv. Opened: 1.12.2025. URL: https://arxiv.org/abs/2504.00636

Li, W., Cui, X., Manoharan, P., Dai, L., Liu, K., & Huang, L. (2025). AI-assisted feedback and reflection in vocal music training: Effects on metacognition and singing performance. *Frontiers in Psychology*, 16, 1598867. Doi: https://doi.org/10.3389/fpsyg.2025.1598867

Merchán Sánchez-Jara, J. F., González Gutiérrez, S., Cruz Rodríguez, J., & Syroyid, B. (2024). Artificial intelligence-

assisted music education: A critical synthesis of challenges and opportunities. *Education Sciences*, 14(11), 1171. Doi: https://doi.org/10.3390/educsci14111171

Muntean, L., & Koren, M. (2022). Self-Singing Solfege and (auto)evaluation – Music literacy for all? In I. Harvey & K. Rees (Eds.), *Proceedings of the 35th ISME World Conference on Music Education* (pp. 216-222). ISME.

Muntean, L., Weidenfeld, S., & Koren, M. (2022). Promoting music literacy since primary school. In M. G. Popescu (Coord.), *Studii de muzicologie* (Vol. 17, pp. 76–89). Iaşi: Editura Artes. ISBN 978-606-547-455-0.

Nichols, B. D. (2014). *The effect of SmartMusic on student practice* (Doctoral dissertation). Kennesaw State University.

O'Leary, E. (2025). Considering the possibilities and problems of AI in music education: The need for critical literacies. *Action, Criticism, and Theory for Music Education*, 24(3), 138–164. Doi: https://doi.org/10.22176/act24.3.138

Popean, M., & Căpăţână, A. (2022). The Appocalypse of Authenticity: AI Faux Music / Apocalipsa autenticităţii. *Tehnologii Informaționale și de Comunicație în Domeniul Muzical,* 14(2), 83–97. Opened: 1.12.2025. URL: https://tic.edituramediamusica.ro/reviste/2022/2/08%20Popean%20Capatana%20-%20ICTMF_ISSN_2067-9408_2022_vol_14_issue_2.pdf

Pop-Sârb, D. (2021). Solfy—O abordare digitală pentru practica solfegiului în şcoală. *Tehnologii Informaționale și de Comunicație în Domeniul Muzical*, 12(1), 21–32. Opened: 1.12.2025. URL: https://tic.edituramediamusica.ro/reviste/2021/1/ICTMF_ISSN_2067-9408_2021_vol_12_issue_1_pg_no_021-032.pdf

UNESCO. (2023). *Guidance for generative AI in education and research*. Paris: UNESCO Publishing. Opened: 1.12.2025. URL: https://unesdoc.unesco.org/ark:/48223/pf0000386047

Wei, X., Zhang, Y., & Li, J. (2022). College music education and teaching based on AI techniques. *Computers & Electrical Engineering*, 100, 107851. Doi: https://doi.org/10.1016/j.compeleceng.2022.107851

Zhang, F., & Zhang, P. (2024). Transforming music education through artificial intelligence: A systematic literature review. *International Journal of Interactive Mobile Technologies (iJIM)*, 18(18), 76–93. Doi: https://doi.org/10.3991/ijim.v18i18.50545