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Toward a transversal education model: a review of digital and artistic-musical competencies (2014–2024)

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ABSTRACT

This study explores the integration of digital and artistic-musical competencies in education, focusing on their potential to foster transversal competencies such as creativity, critical thinking, teamwork, and inclusion. A systematic review of 81 international scientific articles published between 2014 and 2024 reveals that while digital tools are increasingly used in music and arts education, their integration into interdisciplinary and transdisciplinary approaches remains underdeveloped. The findings highlight the benefits of combining technological and artistic competencies for enhancing student engagement, motivation, and skills development. Notably, the COVID-19 pandemic accelerated the adoption of digital tools in education, fostering innovative practices in artistic creation and collaboration. Key methodologies identified include technology-assisted collaborative learning, project-based learning (PBL), technology-assisted collaborative learning, gamification, and service-learning (S-L). However, challenges persist, including unequal access to technology, insufficient teacher training, and difficulties in evaluating competencies developed in integrated learning environments. To address these issues, the study proposes a transdisciplinary education model that integrates digital and artistic competencies into curricula while promoting transversal skills. This model emphasizes active methodologies, inclusive practices, teacher collaboration and holistic evaluation strategies to create an educational ecosystem that prepares students for the demands of a rapidly evolving digital world. The study underscores the need for ongoing teacher training, institutional support, and policy changes to ensure equitable access to resources and effective implementation of transdisciplinary approaches. By fostering creativity and innovation through the convergence of technology and the arts, this model aims to equip students with the skills necessary to navigate the complexities of the twenty first century.

This paper explores the pressing challenges and opportunities in contemporary education by examining the integration of digital and artistic competencies. It highlights the increasing reliance on technology in classrooms and the simultaneous decline in arts and music education, which are critical for fostering creativity and innovation. Recognizing the growing demand for transversal competencies—such as creativity, critical thinking, and collaboration—in the professional world, the study investigates how these competencies can be cultivated through the convergence of digital and artistic education.

To address these challenges, this paper proposes a transdisciplinary education model that integrates digital and artistic competencies into curricula to foster the development of transversal skills. This model is grounded in evidence derived from a qualitative literature review, as detailed in the methodological section.

The findings are structured around three research questions outlined in the study. First, the review examines the integration of artistic-musical and technological languages in education (Q1). Second, it explores how this integration can support the development of transversal competencies such as creativity, inclusion, and teamwork, while also identifying effective methodological approaches (Q2). Finally, the study addresses how institutions and educators can foster a transdisciplinary model that combines music, technology, and the arts to promote these competencies (Q3).

Literature review

The field of education is currently facing a multitude of complex, interrelated challenges that affect educational quality and accessibility (Aróstegui et al., 2015; Yob & Jorgensen, 2020). Two significant issues are,

on the one hand, the integration of technology, which necessitates significant methodological adjustments (Serrano and Casanova, 2022) and, on the other, the overall decline of general artistic and specifically musical education, both of which are essential for the development of children's creative thinking (Aróstegui, 2016, 2017; Bath et al., 2020).

The increasing reliance on technology in education has exacerbated digital inequities, with disparities in access to digital tools and resources among students from different socio-economic backgrounds (UNESCO, 2023). This digital divide affects not only the basic issue of information access but also students' general capacity to fully participate in educational experiences (Cabero-Almenara & Ruiz-Palmero, 2018; Gómez-Trigueros & Yáñez, 2023). Moreover, many educational institutions have difficulty transitioning from conventional educational approaches to new student-focused models based on competencies. Many educators experience difficulties adapting their teaching methods to this new form of pedagogy; as a result, they often apply it inefficiently or incoherently (Kröner et al., 2021).

Simultaneously, there is a general decline of the role played by music and plastic arts in primary and secondary education. The 2024 PISA report (the 2024 Programme for International Student Assessment, based on data gathered in 2022) does not yet include those two fields in its evaluations. However, it does now include an evaluation of creative thinking, defined as the capacity to generate innovative ideas, judge, and improve upon already existent ideas (Cabero-Almenara & Ruiz-Palmero, 2018; Gómez-Trigueros & Yáñez, 2023). This newly included field in PISA studies encourages all those involved in the educational field to encourage students' creative thinking through education by promoting appropriate changes in educational policies worldwide (Ministerio de Educación, Formación Profesional y Deportes [MEFPD], 2024, p. 12).

The aforementioned 2024 PISA report (MEFPD, 2024) reveals two key issues that need to be addressed: on the one hand, the undervaluation of musical and artistic training at the international level and, on the other hand, the need to promote the development of student transversal competencies.

The importance of artistic and, more specifically, musical education has decreased: such subjects are increasingly perceived as irrelevant to a student's future professional success, as they are not part of standard entrance exams (Fernández Navas et al., 2017), which tend to focus on the short-term impact of national education policies on a country's economy (cf. Zamorano-Valenzuela et al., 2024). Arts subjects have thus become undervalued, leading to budget cuts and the elimination of arts programs in favor of "core" subjects such as mathematics and science (cf. Gregory, 2017).

Politicians and the general population thus increasingly tend to view the arts not as essential components of integral education but as mere "icing on the cake." For example, many schools in Spain lack course slots and budgets; moreover, artistic interventions, if they occur at all, tend to be poorly equipped (Calderón-Garrido et al., 2021). When university-level curriculums in the field of education are reformed, less and less priority is given to preparing future educators to teach music and the arts (Cremades-Andreu, 2023; Cuenca et al., 2021). Moreover, in the UK, Bath et al. (2020) analyzed government policies that tend to marginalize music education in British state-run schools; they identified typical symptoms, including "accountability measures, funding cuts, curriculum narrowing and erosion of the teaching workforce" (p. 443).

Conversely, however, the modern market economy increasingly tends to value competencies developed through artistic and musical education: competencies such as creativity and innovative thinking (Samaniego et al., 2024). Holistic music education foments the intellectual, physical, and emotional development of children and youth within a more creative, reflective, and interconnected environment (Abril, 2023). The reduction of music and art as school subjects most probably adversely affects students' ability to develop such crucial skills.

In response to these challenges, there is growing recognition of the need for transversal competencies—skills like creativity, critical thinking, teamwork, and digital literacy—that are applicable across various life contexts, but such skills are not necessarily reflected in standardized tests such as PISA. Although many countries are working toward developing a more comprehensive curriculum promoting holistic competencies, no exhaustive list of such competencies has been established (Aróstegui, 2022). However, there is a consensus that competencies associated with creativity, entrepreneurship, critical thinking, teamwork, and digital skills are transversal: these are fundamental in helping individuals face future challenges as citizens and professionals (Aróstegui, 2022).

UNESCO (2023) has identified ten essential abilities and competencies that enable individuals to navigate it: "Emotional Intelligence, Empathy; Creativity, Critical Thinking; Collaboration; Effective Communication; Complex Problem Solving; Digital Literacy; Learning to Learn; Perseverance or Resilience" (p. 19). These

UNESCO recommendations underscore the relevance of developing generic competencies that can be applied in a wide variety of life situations and educational environments, transcending the barriers of specific school subjects. Such competencies are referred to as "transversal;" they have become a key training element in the educational, social, and professional spheres.

Several current initiatives, including the R&D research project "Transversality, Creativity and Inclusion in School Music Projects: An Evaluative Research" (TCIEM, 2023), seek to promote a more integrated focus on transversal competencies by designing interdisciplinary school projects that promote those competencies' development based on creativity, equal opportunity, digital competency, and an adventurous, entrepreneurial spirit.

The convergence of digital and artistic competencies

Digital competency is defined as the capacity to use technologies critically, safely, and creatively (European Commission, 2021). It not only includes the technical use of digital tools but also the comprehension of how such technologies can transform the way we learn, work, and communicate with one another (Falloon, 2020). Taking these ideas a step further, we regard digital competency as a transversal competency that involves IT alphabetization, communicative and collaborative capacities, the creation of digital content, knowledge about digital safety and protection, and the ability to apply the most appropriate digital tools to solve problems according to the current objective or requirement, as laid out in DIGCompEdu, the European Framework for the Digital Competence of Educators (Redecker, 2017).

"Artistic competency" (often referred to as "cultural and artistic competency") is the capacity to appreciate the importance of the creative expression of ideas, experiences, and emotions through a wide variety of channels, including music, literature, the visual arts, and the performing arts (Alsina & Giráldez, 2012). Artistic competency involves esthetic appreciation, creative expression, cultural understanding, divergent thinking, and the mastery of specific techniques associated with different forms of artistic expression. Artistic competency is a transversal ability that encourages creativity, critical thinking, and cultural sensitivity.

Globally, digital and artistic competencies are becoming increasingly interconnected (Jandrić et al., 2018; King et al., 2017; Treß, 2024). This convergence requires students to merge both. While digital competency prepares students to function and contribute to an increasingly technological world, artistic competency fosters creativity and personal expression, both of which are crucial for innovation and personal and professional development. Interdisciplinary approaches encourage students to apply creative thinking alongside technical skills to solve real-world problems. Such integration not only enhances student engagement but also prepares them for future challenges by developing critical transversal competencies like collaboration and adaptability. This is why integrating digital and artistic competencies represents a transformative opportunity for modern education. By combining technology with creative expression through transdisciplinary methodologies, educators can cultivate well-rounded individuals equipped with the skills necessary for thriving in the twenty first century.

An exemplification of this convergence between digital tools and artistic expression education is the STEAM model (Science, Technology, Engineering, Arts, and Mathematics) (Perales & Aróstegui, 2024; Provorova et al., 2023). It is an extension of the former STEM model, which did not include the arts (Leavy et al., 2023). According to Yakman and Lee (2012), the inclusion of Arts disciplines (with the letter "A") in the STEAM model involves a series of areas associated with Language Arts (including music), Physical Arts (manual and athletic arts); Liberal Arts (Social) (i.e., education, history, philosophy, and politics), and Fine Arts (including aesthetics).

The inclusion of the arts in the STEAM model reflects the increasing awareness that creativity and divergent thinking play a fundamental role in innovation and solving complex problems. By combining artistic methods with scientific and mathematical principles, students develop more complex thinking abilities and participate in innovation by looking for solutions to real-world problems. STEAM projects promote teamwork among students from different specialties, thus preparing them for diversified work environments; moreover, they provide students with a practical application of abstract ideas to concrete proposals with significant effects on real-life situations (Filipe et al., 2024; Perignat & Katz-Buonincontro, 2019).

The current work environment requires versatile employees capable of approaching problems from various angles and suggesting solutions that transcend the limits of traditional barriers among disciplines. It is thus important to prepare students for a job market that values innovation and the capacity for adaptation. With its creative, holistic approach, the STEAM model is designed to help students develop essential transversal abilities.

The progress of the STEAM model has been steady in recent years (Filipe et al., 2024; Perales & Aróstegui,

2024; Perignat & Katz-Buonincontro, 2019), but there is still a long way to go. Aspects such as gender equality in STEAM projects and access of all demographic groups to digital competency are challenges that still require attention. A series of STEAM projects launched by the European Union have started to address these issues of gender integration and economic inequality (European Commission, 2020, 2021, 2024).

Research methods

This paper aims to answer the following research questions in relation to the integration of digital and artistic competencies:

- Q1. What does the international scientific literature reveal about integrating artistic-musical and technological languages in education?
- Q2. How can that integration help students develop transversal competencies (creativity, entrepreneurship, inclusion, socialization, equal opportunity, etc.), and how can that integration be methodologically grasped?
- Q3. How can institutions and educators foment a transdisciplinary model based on the integration of music, technology, and the arts with the aim of encouraging the development of transversal competencies?

To respond these research questions, a qualitative literature review was conducted, making a descriptive and comparative analysis of the source document data with the aim of obtaining the useful, necessary information to respond to our three research questions (cf. Flick, 2007). The search followed several phases. In the first, we analyzed documents published from 2014 to 2024. As we started to establish a bibliography of documents to review, we found them by entering the search keywords "Digital Competence" (OR Digital Skill OR ICT Competence) AND "Music Education" (OR Music) AND "Arts education" AND "STEAM". We examined five multidisciplinary databases: (1) Web of Sciences (WoS); (2) SCOPUS; (3) European Reference Index for the Humanities (ERIH-Plus); (4) Education Resources Information Center (ERIC); and (5) the Arts & Humanities Database.

In the screening phase, our inclusion criteria narrowed our focus down to studies that addressed the integration of digital and artistic competencies in educational contexts. Moreover, we applied further filters: document publication date (2014–2024), document typology (our search was limited to scientific articles), and document language (English and Spanish). Our screening phase led

to the selection of 81 articles that were ultimately included in this literature review: 18 articles from WOS, 18 from SCOPUS, 14 from ERIH-Plus, 19 from ERIC, and 12 from the Arts & Humanities Database.

In the subsequent qualitative literature analysis phase, we observed indicators associated with study contexts, educational level, methodological orientation, and an interdisciplinary orientation that included digital technology, artistic education, and musical education. Derived from this qualitative analysis, we established emergent categories designed to address our three research questions.

In our final discussion phase, based on the data obtained in previous phases, we jointly elaborated the proposal of a transdisciplinary education model designed to encourage the development of musical, artistic, digital, and transversal competencies. This model seeks to create an educational ecosystem that supports the inclusion of artistic-musical and technological competencies in the student training process by encouraging students' creativity, critical thinking capacities, problem-solving skills, and attitudes toward equal access and inclusion.

Findings

Our literature review revealed that only a few documents adopt interdisciplinary approaches to develop digital and artistic-musical strategies. The majority of the articles analyzed focused on digital competency, particularly in higher education and in the area of art and music teacher training. Of these, the majority focused on the use of technological tools and resources in the area of artistic and musical education with the aim of developing digital competencies of students or pre-service teachers. Further texts focused on the impact of COVID-19 in the transformation of teaching methodologies in relation to technology in the teaching and learning processes, in general, and music, in particular. A lesser number of documents referred to experiences based on the STEAM approach and the benefits it can provide in the areas of creativity, teamwork, educational inclusion, critical thinking, and training 21st-century citizenship.

Our selection of 81 articles included documents from 16 countries: Australia, Azerbaijan, Bosnia and Herzegovina, Estonia, Germany, Italy, Portugal, Russian Federation, Spain, Ukraine, and the United Kingdom; from the Americas: Colombia, the United States, and Mexico; and from Asia: China and Hong Kong. Spain was the most highly represented country, with fourteen papers selected for our review. This abundance of texts stemming from Spain may be due to the

emphasis of the current Spanish educational Act (LOMLOE) in the area of training key and transversal competencies in mandatory education and the concomitant repercussions on pre-service teacher training.

In terms of researched academic level, most studies in our selection focused on higher education, particularly on pre-service teacher training and, more specifically, in music teacher training, in line with what Marín-Suelves et al. (2022) elicited. In second frequency of occurrence, our selection featured studies of primary and secondary education; the least quantity of studies was associated with professional teaching of music and non-formal educational environments.

Our result analysis yielded three emergent categories:

1. Development of digital competencies and artistic competencies.
2. Development of transversal competencies and methodological approaches to achieve them.
3. Toward a model based on the goal of transversal education.

Development of digital and artistic competencies

Scientific publications in the field of education are displaying an increased interest in the integration of artistic-musical means of expression and technological skills in the teaching-learning process; not only ever since the dawn of the digital age but particularly more recently in the post-pandemic world (González-Zamar & Abad-Segura, 2021; Leavy et al., 2023; Marín-Suelves et al., 2022).

Several studies point out the benefits of that convergence, which allows students to explore new means of expression (Kröner et al., 2021; Lavrentieva et al., 2023; Samaniego et al., 2024). The increasing incorporation of artistic, musical, and technological competencies in the curriculum also increases their motivation, participation, and engagement in the learning process, not only in formal educational contexts (Calderón-Garrido et al., 2019; Izquierdo & Fernández Maestre, 2020) but also in non-formal ones (Schols & de Haan, 2016). Artistic and musical competencies are thereby tangibly improved, and students can develop digital skills that are essential for the twenty first century (Kröner et al., 2021; Leavy et al., 2023; Mascarell, 2019; Papanastasiou et al., 2019). The convergence of these means of expression facilitates a more holistic and interdisciplinary orientation of the teaching-learning process, encouraging students to find connections among diverse areas of knowledge (Dragone & Rosa-Napal, 2021; Samaniego et al., 2024).

Digital and artistic competencies in teacher training and professional development

The articles we consulted shed light on teachers' technological competencies in the context of integrating the latter with the arts. Studies conducted by Asad et al. (2021) and Calderón-Garrido et al. (2021) identified a considerable gap between teachers' competencies and the technological competencies required for effective classroom integration.

Teacher attitudes toward technology are essential on the road toward their effective adoption and integration (Bravo Villares & Fernández Sánchez, 2022; Colás-Bravo & Hernández Portero, 2014; Mateos-Moreno & Bravo-Fuentes, 2023). The latter studies showed that positive perceptions regarding the usefulness and ease of use of technologies are correlated with a greater integration of technologies in teachers' day-to-day practice. The literature in our review identified a series of specific technological competencies that are necessary for the effective integration of artistic and musical education: knowing how to use audio and video editing software, familiarity with digital creator platforms and online collaboration tools (Colomo & Cívico, 2023; Morreale, 2022; Peñalver & Porta, 2021).

The scientific literature also highlights the relevance of technological competencies in pre-service teacher training, particularly in the areas of artistic and musical education (Stojanović, 2023; Usca et al., 2024; Wan, 2022). Studies show that teachers with solid training in educational technologies are more likely to integrate these tools into their pedagogical practice. For example, research by Calderón-Garrido et al. (2021), Cheng et al. (2024), Cremades-Andreu (2023), Mateos-Moreno and Bravo-Fuentes (2023), and Palau et al. (2019) show a persistent gap between teachers' recognition of the importance of technology in artistic education and their practical ability to implement it effectively. This gap is also attributed to a lack of specific training in using digital technologies to teach music and the arts.

Indeed, the training of technological competencies should not be limited to mere technical knowledge; it should also include the capacity to integrate those tools effectively in day-to-day educational practice and pedagogy. University students should be given several occasions to try out different methodologies during their pre-service teacher training (Rizzi et al., 2023; Usca et al., 2024), because the mere use of digital resources in the classroom is not necessarily accompanied by methodological transformation. An effective integration of technology requires constant feedback

between technology, curricular content, and pedagogical methods (Serrano & Casanova, 2022).

Continuous teacher training in the area of educational technologies is another critical factor for improving teachers' digital competencies. Asad et al. (2021) and Bravo Villares and Fernández Sánchez (2022) demonstrate that well-designed professional development programs significantly improve teachers' digital competencies, problem-solving abilities, and communication capacity (Leoste et al., 2022; Song, 2020). These programs also help bridge the gap between theoretical knowledge and practical application in real-world classrooms (Serrano, 2017).

Digital and artistic competencies in the education of students

Although research in this field remains limited, the scientific literature analyzed offers evidence that developing technological competencies in students is better achieved by combining artistic-musical means of expression with technological know-how (Mono Castañeda, 2023; Sáez-López & Sevillano-García, 2017). Such integration can help students improve their manner of searching, selecting, and managing information and how they deal with creating and editing multimedia content. It also encourages the development of computational thinking, online collaboration abilities, and the effective use of digital communication tools (Cremades-Andreu & Campollo-Urkiza, 2023; Rohotchenko et al., 2021). Further studies (e.g., Della Ventura, 2021) indicate that incorporating technology in the learning process helps music students find solutions they can apply to problems they encounter in their interpretation of instrumental repertoire. It also allows them to become active participants in the classroom.

Despite these evident benefits, several challenges prevent on integrating artistic-musical and technological approaches. One significant issue is the persistence of inequalities in access to technology, which disproportionately affects students from lower socio-economic backgrounds (Cabero-Almenara & Ruiz-Palmero, 2018). Additionally, many educators lack the necessary training to design and implement meaningful proposals that integrate these competencies (Calderón-Garrido et al., 2021; Cheng et al., 2024).

Another challenge lies in evaluating competencies developed within integrated learning environments. Dias-Trindade & Moreira (2020) observed that traditional assessment methods often fail to capture the multifaceted nature of competencies such as creativity and collaboration. Similarly, Suvorov et al. (2022) found that while students often exhibit high general digital competency, they frequently struggle with specific tasks related to creating and modifying artistic or musical digital content.

The impact of COVID-19

Before the COVID-19 pandemic, scientific literature in our field was already showing an increasing interest in integrating arts, music, and technology in education. After that, the pandemic acted as a catalyst for digital reception and transformation in the educational field, accelerating the adoption of certain technologies and redefining the integration of music and the arts in the teaching-learning process. This phenomenon was widely documented in recent scientific literature (e.g., Biasutti et al., 2023; Domínguez-Lloria & Pino-Juste, 2021; Sabol, 2022). These articles noted the rise of digital platforms and digital artistic creation tools: these have become quasi-omnipresent and make it easier for users to find new means of artistic and musical expression. The need for flexibility led to an increase in the use of open-source educational resources and asynchronous learning platforms; this, in turn, allowed students to explore artistic and musical content at their own pace (in formal academic as well as non-formal educational environments). Thus, new forms of artistic and musical collaboration emerged online, encouraging creativity and virtual social connections.

In addition to this increase of the implementation of digital tools, the systematic review suggests that the pandemic has likewise exerted a long-term impact on the integration of arts, music, and technology in education (Begić & Šulentić, 2023; Buchborn et al., 2022). Authors observed a tendency toward learning models that combine face-to-face and virtual situations (blended learning models), taking advantage of each one's most useful characteristics. Adaptive technologies and artificial intelligence are being increasingly used to personalize artistic and musical learning experiences (Li, 2020; Marzal & Vivarelli, 2024). Virtual and augmented reality are also on the rise. These technologies are being adopted in musical and artistic education to create immersive experiences, leading to new forms of expression and esthetic appreciation (Cebrián et al., 2024; Innocenti et al., 2019; Papanastasiou et al., 2019; Soroko et al., 2021).

Although the transition to online teaching presented a series of significant challenges, it also opened new possibilities for using numerous apps and for musical collaboration at a distance. Biasutti et al. (2023) and Cheng et al. (2024) noted the need for artistic education to maintain a balance between technological integration and traditional practices. In their studies, they concluded

that although technologies present unique opportunities, they should not wholly replace practical, face-to-face experiences in artistic and musical learning.

Development of transversal competencies and applied methodological approaches

The development of transversal competencies

Few studies focused on analyzing interdisciplinary proposals based on arts, music, and technology from the perspective of developing transversal competencies. Research by Usca et al. (2024) and Samaniego et al. (2024) highlights the potential of such approaches to enhance creativity, critical thinking, problem-solving, and personal development competencies. These studies also emphasize that transversal learning is studied more in secondary education than in other academic levels (Calderón-Garrido et al., 2021).

The interdisciplinary focus inherent in the STEAM approach allows teachers and students offers significant advantages for developing transversal competences. Research by Filipe et al. (2024), Quigley and Herro (2016), and Sanz-Camarero et al. (2023) found that the integration of the arts in STEAM educational models promotes creative competency, empowerment, and decision-making, given that the STEAM methodology has proven more efficient in tackling problems and finding divergent solutions. This, in turn, foments the development of mental frameworks and improves comprehension expertise.

Depending on authors, the STEAM proposal is viewed from an interdisciplinary or transdisciplinary angle; the latter is optimal for daily problem-solving (Lin & Tsai, 2021). Perales and Aróstegui (2024) point out the usefulness of projects such as *Global Science Opera, The Imagineerium* and *GetWet* as good examples of transdisciplinary projects where music and the arts are on a par with other areas. However, Sanz-Camarero et al. (2023) pointed out that few projects in preschool and primary education have authentically and significantly incorporated the arts into STEAM proposals. This underscores the need for educational policies that promote greater transdisciplinary integration based on music and the arts.

Beyond STEAM initiative, other interdisciplinary artistic proposals mediated by technology have yielded comparable results in terms of creative development, critical thinking, and social interaction. For example:

- **Primary Education:** Sáez-López and Sevillano-García (2017) analyzed the use of Scratch with sensors to combine computational thinking with arts education.
- **Secondary Education:** Projects such as cultural e-snapshots (Colomo & Cívico, 2023) or interdisciplinary audiovisual productions (Dragone & Rosa-Napal, 2021) have shown positive outcomes.
- **Pre-Service Teacher Training:** de Moya and Syroyid (2021) explored creating musical stories for didactic purposes.

In non-formal education environments, further projects combining digital and artistic-musical competencies have improved student motivation, logical-mathematical thinking, and learning of musical concepts. Examples include the Bee-Bot educational robot (Torrejón & Ventura-Campos, 2019) and several iPad applications including Cubasis, Studio.HD, IMPC, Looptastic HD, and Loopy HD, all of which encourage creativity and immersion, leading to new curriculum perspectives (Order, 2015). Further integrative experiences use social media and platforms such as YouTube and X (Twitter) (Monreal-Guerrero & Herrero Gozalo, 2023), educational blogs (Carrión & Pérez Agustín, 2020), and augmented reality tools (del Moral et al., 2022) to develop not only digital/artistic competencies, critical thinking, and creativity, but also a series of communicative, social, and teamwork abilities. Although the literature on incorporating artificial intelligence in education is still scarce, certain studies have already noted positive results. One example is the project developed by Parada-Cabaleiro (2024), who used generative tools to encourage the co-creation of content emerging from a collaboration between children and an AI. This project encouraged an integrative development of those children's digital and artistic competencies.

Inclusion through arts and technology

Technology, when incorporated into arts and music education, helps students develop social competency and a more inclusive attitude (Carrión & Pérez Agustín, 2020; Wellington et al., 2020). In what refers inclusion of students with special needs, the following experiences were found:

- Moreno et al. (2023) used Accessible Digital Musical Instruments to provide inclusive access for children with cerebral palsy in Portugal.
- Cano and Sánchez-Iborra (2015) demonstrated how PLAIME software supported students with disabilities in acquiring musical knowledge while enhancing their perceptual and social skills.
- Hillier et al. (2016) reported an arts-and-technology experience with students on the autistic

spectrum which proved to reduce their stress and anxiety.

- Chao-Fernandez et al. (2017) inquired programs for the inclusion of students with hearing deficiencies. She found that such programs favored their inclusion by supporting their motivation and integration.

These inclusive initiatives underscore the potential of digital technology to create equitable opportunities for all learners while fostering empathy and self-regulation through multisensory learning experiences (Kastner et al., 2020;; Marín-Suelves et al., 2022; Usca et al., 2024).

As for social inclusion, other projects combining music and technology encouraged the cultivation of social values, a greater acceptance of diversity, and a notable improvement in the general atmosphere in the classroom (Rodrigo-Martín et al., 2020; Rovithis et al., 2019).

Methodological approaches and educational strategies

The educational experiences documented in the literature coincided in that they used innovative methodological approaches based on active learning and promoting the use of digital technology as a key educational resource in teaching-learning processes, as applied both to art school subjects and to others of an interdisciplinary and transdisciplinary orientation.

First, technology-assisted collaborative learning was one of the most commonly used methodological approaches in our sample. Palazón-Herrera (2021) demonstrated its efficacy in supporting high-school-level music students in building creative projects and as an efficient means for developing creativity and empowerment. Technology-assisted collaborative learning also improved student motivation, student social abilities, and academic performance; however, project length, organizational complexity, and previously preparing the group's social skills were determinant factors for the improvement of results. Arriaga and Riaño (2017), Maheirie and Barreto (2019), and Murillo et al. (2019) all highlighted the social construction of knowledge and learnings through methodologies based on collaboration.

Project-based learning (PBL) was another prominent methodology, particularly within STEAM-focused studies. Domènech-Casal (2018) identified the core components of PBL: (1) the teaching process derives from a particular context, situation, or problem; (2) contents are learned within that context's framework

and give rise to group activities; and (3) the teacher needs to pose a challenge that should be identified as such as and tackled by all participants. Several studies demonstrated positive results associated with the PBL approach: for instance, in collaborative work on audiovisual creation (Sáez López & Sevillano-García, 2017), in student autonomy searching for solutions in the area of musical interpretation (Della Ventura, 2021) and in activating children's critical thinking in musical composition activities (Parada-Cabaleiro, 2024) following the application of interdisciplinary experiences.

A third methodological approach identified was inquiry-based learning. It proved to be beneficial for students (Ortiz-Revilla et al., 2021) to seek creative solutions and ideas within the framework of scientific, technological, and/or artistic thinking. The STEAM model served as one of the points of reference.

Fourth, studies also emphasized student-based learning (SBL) as a transformative strategy for fostering active engagement. Della Ventura (2021) examined the transformation from a more passive to a more active learning focus by applying technology in music instrument performance training. Shi (2023) explored ten mobile apps designed for vocal training; she highlighted the symbiosis between the area of music pedagogy and the technological domain, resulting in constructive feedback for students, leading to a more personalized approach to vocal training. In pre-service teacher training, de Moya and Syroyid (2021) presented the ecological approach as a teaching strategy combining music and an interdisciplinary orientation associating creativity, technology, and the human-oriented aspect in an audiovisual production experience.

Fifth, gamification emerged as a motivational learning that entirely transform a reward system formerly focusing on grades (numerical scores) into a new type of challenge, the students must face throughout their learning process (Domínguez-Lloria et al., 2023). The implementation of digital apps in the area of music composition served as a motivational strategy for music learning, particularly for students who had no experience playing a musical instrument (Chen, 2020). Similarly, Slađana (2015) used online games and gamification tools to motivate children enrolled in an international arts program to learn music and dance in English; the apps increased equal access and motivation. Further types of synergies between technology and music can give rise to immersive experiences for adolescents who habitually use social media to create collective, interactive exchange experiences inside and outside the classroom (Domínguez-Lloria et al., 2023).

Service-learning (S-L), requiring teachers to apply digital technologies beyond traditional classroom settings while addressing socio-educational challenges, is the sixth and last approach identified, albeit with less frequency. Cuervo et al. (2023) found that the S-L approach involves several challenges for music teachers, they need to: (1) have in-depth knowledge of digital technologies; (2) acquire the necessary competencies that allow them to apply that knowledge outside the traditional classroom framework; (3) apply appropriate didactic, musical, and technological strategies; and (4) reflect socio-educationally about how students use digital tools.

These interdisciplinary methodological strategies should transform the way teachers evaluate student competencies; however, the documents analyzed did not always explicitly reflect such a transformation. It seems evident that approaches based on interdisciplinarity and the development of transversal competencies should introduce a series of flexible, open, holistic strategies that allow teachers to observe, identify, and value the teaching efficiency of different tools. Within an interdisciplinary, technological framework, certain projects that expose artistic results to an audience—such as music, dance, and theater performances—show us how an "authentic evaluation" should be achieved. "Authentic evaluation" should be more creative, less restrictive, and it should seek to evaluate processes instead of results (Palazón-Herrera, 2021).

Self-evaluation and co-evaluation strategies in the area of interdisciplinary training should generate active situations that motivate students to explore learning processes in-depth, searching for new solutions and valuing their learning results from a critical, holistic perspective (Filipe et al., 2024).

Toward a model based on transversality

The primary objective of this study was to propose an educational model based on transversality that effectively integrates the aforementioned competencies into the academic curriculum. This aim directly addresses the third research question (Q3) built upon findings from Q1 and Q2.

Current landscape and challenges

Our literature review revealed that most studies focus on using technological applications in music and arts education, primarily to develop student digital competencies using musical and artistic tools and content. While these studies demonstrate the technical and instrumental benefits of such integration—such as the use of mobile apps and digital resources—they often neglect the broader goal of fostering transversal competencies like creativity, socialization, inclusion, and teamwork. Additionally, the integration of artistic-musical and technological languages remains underexplored in terms of its potential to develop critical thinking, problem-solving, and personal growth competencies (Samaniego et al., 2024; Usca et al., 2024).

Despite these shortcomings, the convergence of technology with artistic-musical activities offers a promising outlook for enriching educational processes (González-Zamar & Abad-Segura, 2021; Leavy et al., 2023; Marín-Suelves et al., 2022). Evidences from the literature review highlight that such integration has many benefits, ranging from the development of digital, *viz.* artistic-musical competencies to the development of other essential transversal competencies, such as creativity, problem-solving, socialization, inclusion, equal access, and teamwork, and the development of personal character competencies including self-esteem and the capacity of learning how to learn (Samaniego et al., 2024; Usca et al., 2024).

Although the importance of such competencies is widely acknowledged, educational policies and institutions frequently overlook them, citing time constraints, extensive curricula, and other unproven arguments (Aljughaiman & Mowrer-Reynolds, 2005). For this, our literature review reflected the need for a genuinely transdisciplinary integration based on artistic-musical expression (Lin & Tsai, 2021; Sanz-Camarero et al., 2023)—an integration which, until now, has been challenging to achieve.

Integrating artistic-musical and technological languages in education represents a significant opportunity to enrich the educational experience of all students and should be considered as part of the core subjects (Allina, 2017). These results suggest that the convergence of art, music, and technology with the rest of the areas considered "core subjects" in education not only involves an evolution of pedagogical practices but can also be an effective strategy to reimagine the teaching-learning experience and prepare students for the challenges of the twenty first century, in which creativity, adaptability, and digital literacy have become fundamental.

The COVID-19 pandemic accelerated the integration of artistic, musical, and technological languages in education. This convergence offers unprecedented opportunities to enrich the educational experience and prepare students for an increasingly digitized world evolving at breakneck speed and with unpredictable parameters. In the post-COVID-19 pandemic

era, educators, policymakers, and researchers must continue to explore and evaluate best practices for this integration to ensure that all students can benefit from these educational innovations, regardless of gender, culture, or cognitive/physical abilities.

However, significant challenges are evident, particularly in terms of teacher competencies, both in technical and methodological knowledge and in didactic strategies that allow the application of transdisciplinary proposals that are genuinely significant and balanced among the different areas (Allina, 2017; Perales & Aróstegui, 2024; Provorova et al., 2023). This implies the need for more solid teacher training to close the gap between the competencies required and those currently possessed by the teaching staff (Allina, 2017; Asad et al., 2021; Bravo Villares & Fernández Sánchez, 2022; Calderón-Garrido et al., 2021), while prioritizing equal access despite inequalities. Our literature review underlines the need for more effective and tailored continuing education programs to ensure a successful and equitable implementation of these integrated educational approaches. Educational policies should encourage and support this type of teacher training.

Likewise, adequate funding should cover the spaces and material and human resources required for the implementation of transdisciplinary proposals (Allina, 2017; Asad et al., 2021; Calderón-Garrido et al., 2021). At the same time, the administrators of educational institutions should provide recognition, incentives, and flexible time schedules. Success will largely depend on the education system's ability to develop teachers' technological competencies and provide the necessary resources for effective implementation.

To achieve these objectives, fostering collaboration among teachers, promoting integration among curricular areas, and investing in educational institution infrastructures that facilitate such integration is key. Further research is also needed in this area, especially regarding assessment methodologies and the long-term impact of these integrated approaches on students' academic and professional development. It is also crucial to maintain a critical and reflective approach regarding how these proposals are implemented to ensure that artistic and musical learning is not relegated to an inferior level in the curriculum and in society.

Regarding methodological approaches, our review identified several emerging models that seek to transversally integrate digital and artistic competencies, such as the STEAM model, which incorporates the arts ("A") into the traditional STEM focus. The STEAM approach promotes creativity and design thinking in technical disciplines, learning experiences based on digital projects (combining artistic creation with technological tools to solve real-world problems), and interdisciplinary learning spaces that combine technology, art, and design to stimulate innovation. By adopting active, innovative methodologies inside and outside the classroom (including non-formal educational environments), the STEAM model can potentially become an integrative approach capable of helping students simultaneously develop digital, artistic/musical, and transversal competencies.

Suggesting an educational model based on transversality

Based on our findings, we propose a transdisciplinary educational model designed to integrate and combine digital and artistic competencies while working on developing transversal competencies. The key elements of this model include:

- Transdisciplinary projects: designing learning experiences that require the simultaneous implementation of artistic/musical abilities along with digital skills on a par with abilities traditionally associated with core subjects, thereby progressing toward a truly integrative STEAM model.
- Teacher training and teamwork: designing robust training programmes that equip educators with both technical and pedagogical skills. Collaboration among teachers from different curricular areas is essential to create cohesive transdisciplinary approaches.
- Development of transversal competencies: focusing on creativity, critical thinking, teamwork, inclusion, and problem-solving as core outcomes of integrated learning experiences.
- Inclusive proposals: ensuring equal access to education by accommodating diverse student needs regardless of gender or cognitive/physical abilities.
- Active methodologies: Employing student-centered approaches such as project-based learning (PBL), gamification, and inquiry-based learning to engage students as active participants in their education.
- Technology as a creative tool: using digital technologies not only as functional tools but also as mediums for artistic expression and innovation.
- Critical thinking: encouraging students to analyze and create content that combines digital and artistic perspectives with ethical considerations.
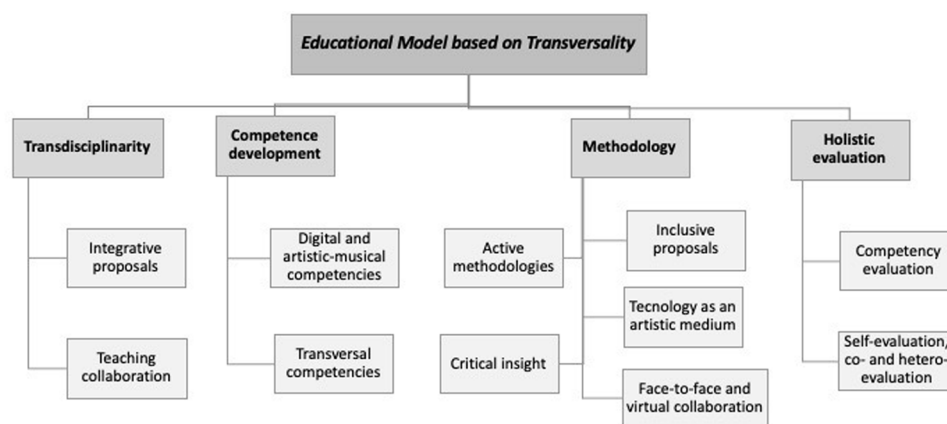
Figure 1. Summary of the educational model based on transversality.

- Collaborative environments: Promoting both face-to-face and virtual collaboration through synchronous and asynchronous platforms to enhance teamwork and communication skills.
- Holistic evaluation: Implementing flexible assessment methods that value process over results. Self-evaluation and peer evaluation should be integral components of this approach.

To conclude, this proposed model seeks to create an educational ecosystem where digital and artistic competencies help students develop transversal competencies. By fostering creativity, adaptability, and innovation through transdisciplinary methodologies, this model prepares students for a future in which creativity, art and technology will be inextricably linked (Figure 1).

To successfully implement this model, ongoing teacher training programs must address gaps in technical knowledge and pedagogical strategies. Additionally, institutional support in the form of funding, infrastructure development, and policy alignment will be critical for achieving meaningful integration across disciplines.

In summary, adopting this transdisciplinary approach will not only enrich students' educational experiences but also equip them with the skills needed to navigate an increasingly complex world. Further research should focus on evaluating the practical application of this model across diverse educational contexts to ensure its long-term impact on student learning outcomes.

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