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# Music Education and technology: trends in research[1]

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**Abstract.** Technology has been integrated into the different curricular areas since the digital competence is considered a key competence and its consequent impact on educational policy in different countries. This phenomenon has also affected Music education, for which technology has great potential. This study focuses on the relationship between technology and Music Education from a bibliometric and bibliographic approach. On one hand, research was carried out on scientific production in quantitative terms, based on the analysis of the 161 selected articles from the Web of Science and Scopus databases and, on the other hand, the content of the 55 publications available in open access. Results confirm the increase in relevant scientific production over the past 5 years and the predominant positions of the United States and Spain. It also highlights the pre-eminence of research focused on higher education, students and teachers being the main participants. The variety of technology implemented in training processes is also noteworthy, as well as its positive impact not only on aspects related to the discipline itself, but also on the development of transversal competencies.
**Keywords:** Music education; educational technology; bibliometrics; bibliographics.

## [en] Educación Musical y tecnología: tendencias en investigación

**Resumen.** La tecnología se ha integrado en las diferentes áreas curriculares por la consideración de la competencia digital como competencia clave y su consecuente impacto en la política educativa de los diferentes países. La Educación Musical no ha quedado ajena a este fenómeno, considerándose la tecnología como una herramienta con un potencial reseñable para su desarrollo. Este estudio trata de aproximarse a la relación entre tecnología y Educación Musical desde un enfoque bibliométrico y bibliográfico: por un lado, se indaga sobre la producción científica en términos cuantitativos, a partir del análisis de los 161 artículos seleccionados de las bases de datos Web of Science y Scopus y, por otro, se analiza el contenido de las 55 publicaciones disponibles en abierto. Los resultados confirman el aumento de la producción científica en los últimos 5 años y las posiciones predominantes de Estados Unidos y España. Destaca, asimismo, la preeminencia de investigaciones centradas en la etapa de Educación Superior, con alumnado y profesorado como principales participantes. Asimismo, es reseñable la variedad de tecnología que se implementa en los procesos formativos, así como su impacto positivo no solo en aspectos relacionados con la propia disciplina, sino también en el desarrollo de competencias de carácter transversal.
**Palabras clave:** Educación musical; tecnología educativa; bibliometría; bibliografía.



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### 1. Introduction

Over the past few decades, educational policy in different countries has promoted the integration of technologies into the realm of teaching-learning. On the one hand, technological equipment has been incorporated into classrooms at

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different stages. On the other, international guidelines have tried to promote digital competence as a key citizenship skill (European Commission, 2006; European Council, 2018). Therefore, a variety of different technologies (including hardware, software, and 2.0 technologies) have been incorporated into music education, due to its great potential in pedagogical practice and learning processes for all the involved in the education community.

Even though different perspectives are offered for various geographical, cultural, and social contexts, as well as for each institution's approach to the Music Education curriculum (Cox & Stevens, 2017), there seems to be a certain consensus about technology's increased content and methodological weight in the discipline (Serrano, 2017). However, there is still a long way to go before its potential can be fully attained.

### 1.1. Research axes: Music education and technology

The relationship between music and technology has evolved parallel to its development and application and its integration into human life. The educational field, and more specifically didactics, has become one of the greatest exponents (Giráldez, 2013). Presently, this binomial has become especially relevant and technology has developed new dimensions in times of the 2020 pandemic in all areas including Music Education (Hash, 2021; Schiavio et al., 2021).

As such, music technology has gradually established itself as a specific tool for formative processes associated with the learning of various subjects, such as singing, movement or performance (De Castro, 2015), instrument learning (Liu & Liu, 2017), music theory (Li, 2017; Carrascosa & Carrascosa, 2021). Even the economic impact of music technology (Barneva et al., 2021), some authors such as Gorbunova (2020) consider that it has become a discipline in its own right, rather than a combination of independent areas of knowledge.

However, its application seems to differ depending on the educational stage in which technology is integrated into Music Education. Specific software is more commonly designed for training processes in Early Childhood Education, while the implementation of technologies with a recreational component is more common in Primary Education. In Secondary Education, it is approached from a more transversal point of view, and in Higher Education technology is prioritised in hybridisation processes (Calderón-Garrido et al., 2019).

Nevertheless, specific hurdles must be overcome so that technology can be effectively applied to Music Education. Teacher training is a key element (Väkevä, 2017), where practical experiences combining music and technology have also been carried out (Sadio-Ramos et al., 2021). Currently, there is a diverse initial training landscape, not only nationally (Calderón-Garrido et al., 2020), but also internationally (Domínguez-Lloria & Pino-Juste, 2020). However, this does not guarantee the development of specific digital competence skills and makes evident the need for lifelong learning programmes (Martín & Arriaga, 2019). Furthermore, some differences have been found depending on the educational stage, with a greater predisposition for the integration of technology in Music Education among future Primary School teachers than among Pre-school teachers (Atabek & Burak, 2020). Furthermore, this predisposition does not always result in the actual implementation of technology in Music Education (Calderón-Garrido et al., 2021).

### 1.2. Bibliometrics approaches: background

The scientific literature in the field of technology and Music Education has increased exponentially, along with the digitalization of other disciplines. The publications have tried to focus on the combination of these two realities through different types of proposals. Some contributions have attempted to compile examples of good practice in bibliographic reviews (Jorquera, 2017) and others have adopted a bibliometric approach. The latter has been used in the field of Music Education, but not directly in relation to technology. Gustems & Calderón (2014), for example, analysed scientific production in the Dialnet database, concluding that Spain had a greater number of indexed journals with scant research and little dissemination in conservatories and universities. Likewise, Galera and Pérez (2008) focused their bibliometric analysis on the ERIC database and stated that the scientific papers on music education were concentrated in four major journals (none of them indexed in JCR). These were usually signed by a single author, with no signs of academic corporatism in the scientific production. Along the same lines, Morales et al. (2017) based their study only on data from Spain and concluded that the literature was scattered in journals from other areas and had little impact in comparison with other areas of knowledge.

The predominant psychological and pedagogical approach was confirmed also by Gustems & Calderón (2016) in a study based on the production available in Scopus. In this case, they concluded that scientific production was mostly published in English, the United States being the country with the most publications, these being papers written by a single author with limited citations. Furthermore, almost half of the publications analysed were found in 5 journals, mostof them in the *International Journal of Music Education, the Journal of Music Education,* and *Music Education Research.*

### 1.3. Research objectives

Based on the above, the main objective of this work is to carry out a systematic review of the scientific literature on Music Education and Technology by means of a bibliometric analysis. Likewise, a review of the narrative

in the literature is proposed, by conducting a content analysis. For the bibliometric review, the main trends in scientific activity over the last two decades were analysed. For content analysis, the variables studied were the target educational stage of the studies, their curricular approach, the use they make of technology, and the main results obtained.

## 2. Methodology

This work consists of two mutually complementary studies: a systematic bibliometric review and a narrative review based on content analysis. From a scientometric perspective, the bibliometric study was designed to analyse scientific activity based on quantifiable features (Tomás-Gorriz & Tomás-Casterá, 2018). This methodology has proven to be very useful for research in the Educational Sciences (Romera, 1992). In this case, it is applied to the use of technology in Music Education. The Scopus database was chosen for the analysis due to its extensive historical coverage and the number of documents per area (Hernández et al., 2016), and WOS was chosen to overcome limitations found in previous studies (Abad-Segura et al., 2020).

The keywords used in the search in combination with the Boolean operators were: *technology* and *music education*. From a total of 589 results, 161 documents were selected for analysis, after introducing several filters: document type (papers), publication time (since 2000, to analyse the production carried out in the present century), and area (social sciences, arts and humanities). The following inclusion criteria (shown in Table 1), were taken into account based on those established in previous studies (Sola-Martínez et al., 2020).

Table 1. Selection criteria

| VARIABLES | INCLUSION CRITERIA |
|---|---|
| Databases | Renowned international databases: Scopus and WOS. |
| Keywords | technology AND music education. |
| Year of publication | 2000–2020. |
| Document type | Scientific papers. |
| Area of research | Social Sciences / Arts and Humanities. |
| Country | No exclusion criteria. Countries with more than 10 papers were analysed. |
| Journals | Journals with more than 5 papers were analysed. |
| Languages | No limitation. |
| Citations | Papers with more than 50 citations were analysed. |
| Authors | Authors with more than 5 papers were identified. |
| Bibliometric map | Including keywords with more than 5 occurrences. |

Table 2 shows the exclusion criteria used to eliminate documents and reduce the final sample for the study.

Table 2. Exclusion criteria

| EXCLUSION CRITERIA |
|---|
| Typologies other than papers. |
| Literature review works, designs without implementation or validation of instruments. |
| Documents written prior to the year 2000. |
| Documents written from areas other than Social Sciences / Arts and Humanities. |
| Redundant papers included in both databases. |
| Documents that did not focus on the object of study: Music Education and technology. |

The process, following the PRISMA Statement (Urrútia & Bonfill, 2010), is shown in Figure 1.

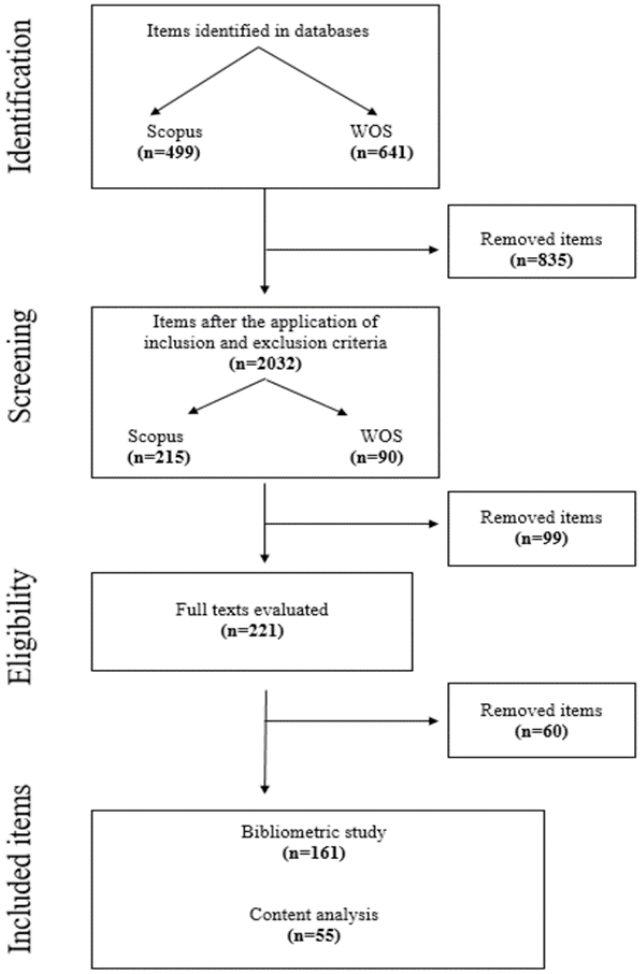


Figure 1. Flowchart showing the process of selection of documents

The agreement between raters was considered good, with a Cohen's kappa coefficient of k=0.78.

From a bibliometric perspective, the data analysis took the variables described by Acuña et al. (2018) regarding scientific productivity, collaboration, impact, and scattering (Table 3) into account. Vosviewer 1.6.11 (Van Eck & Waltman, 2017) was used to represent the results and SPSS 25 was used to calculate correlations.

Table 3. Bibliometric indicators

| INDICATORS | CATEGORIES OF ANALYSIS |
|---|---|
| Scientific productivity | Number of publications in the selected areas, date of publication according to Price's Law, country of publication, and language. |
| Collaboration | Co-authorship. |
| Impact | Number of citations, key researchers, Lotka's Law, journals with the most publications, and impact factor. |
| Scattering | Areas, following Bradford's Law. |

On the other hand, content analysis was carried out (Manning & Cullum-Swan, 1998) from an inductive perspective, based on the coding and selection of categories that emerged after reading the texts. A record sheet was prepared ad hoc (Table 4), differentiating several categories of analysis (Friberg & Öhlen, 2007). The 55 articles available in open access were included in the content analysis.

Table 4. Registration card

| CATEGORY | SUBCATEGORIES |
|---|---|
| Educational stage | Pre-primary Education, Primary Education, Secondary Education, or Higher Education. |
| Participants | Educators, students, educational managers, other participants. |
| Approach to music education | Specific subjects in the curricula or transversal approach. |
| Technologies for implementation | Software, hardware, or 2.0 technologies. |
| Use of technology | Hybridisation, learning of theoretical content, instrumental learning, communication and collaboration, digital learning devices, transversal competences. |
| Results | Impact on academic performance, motivation, instrumental skills, and transversal competences. |

## 3. Results

### 3.1 Bibliometric analysis

The results of the bibliometric study were organised into variables such as scientific productivity, collaboration, impact, and scattering of publications related to the use of technology in Music Education.

#### 3.1.1 Productivity

In terms of scientific productivity, we considered papers in the areas of Social Sciences and Arts and Humanities, published from 2000 to the present day, and also taken into account were the place of publication and the language in which they were written.

Of the total results obtained in the search, 80.1% belonged to the area of Social Sciences and Arts and Humanities. These were the ones analysed in this study, while other texts from Medicine (0.6%), Engineering (1.2%), Psychology (3.6%), and Computer Science (19.9%) were excluded.

The number of publications has increased in recent years, so we can confirm that the study of the relationship between Music Education and technology is on the rise, as stated in Price's law. Figure 2 shows the data obtained regarding the number of publications per year. As can be seen, almost half of the articles (47.2%) were published in the last five years, and more than ⅘, in the last decade (83.9%).

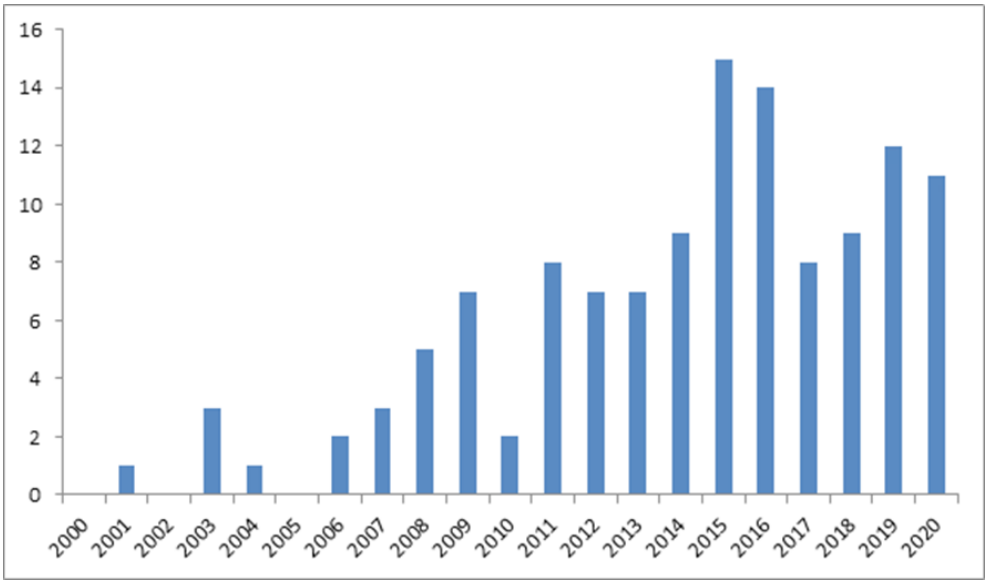


Figure 2. Publications by year. Source: created by the authors.

The most productive countries are the USA (37), Spain (36), the UK (20), and Australia (12). Additionally, 37 other countries across different continents have at least one publication on this topic, which is indicative of the widespread global interest in this issue. When considering the differences in population, higher education institutions, or Gross Domestic Product, Spain's position deserves to be acknowledged. The reasons that may justify this predominance are the long musical tradition of the country, the use of the search term Musical Education, which matches the subject title in the Spanish official curriculum, and because the subject is compulsory for most years of obligatory schooling.

When considering the language of the published articles, English stands out as the language of choice for the dissemination of results, accounting for 78.9% of the total. This is followed by Spanish (18.6%) and Portuguese (1.9%). In addition, there is only one article published in other languages such as Croatian (Vidulin-Orbanić & Duraković, 2011), Russian (Malykhina, 2019), or Turkish (Aksu, 2015).

### 3.1.2 Collaboration

Regarding this aspect, almost half of the articles are signed by a single author (42.9%), while the rest are co-authored, most commonly by researchers from the same institution, from nearby universities, or from intranational networks. The work by Nouwen et al. (2016) has the highest number of authors with a total of 6, belonging to three Belgian institutions. Table 5 shows the frequency and percentages based on the number of authors.

Table 5. Frequency and percentage of papers by number of authors

| AUTHORS | N | PERCENTAGE |
|---|---|---|
| 1 author | 69 | 42.9 |
| 2 authors | 53 | 32.9 |
| 3 authors | 23 | 14.3 |
| 4 authors | 9 | 5.6 |
| 5 authors | 6 | 3.7 |
| 6 authors | 1 | 0.6 |

### 3.1.3 Impact

Thirdly, to analyse their impact, the number of citations of each paper was considered along with the key researchers in this field of study, and the journals with more published papers on this subject. Regarding the number of citations, the works by Savage (2007), with 54 citations, and Bauer et al. (2003), with 52, stand out. Only two items accumulate more than 50 citations. Most frequently in this field, papers have either none (34.8%) or less than 10 references (43.5%), as shown in Table 6.

Table 6. Frequency and percentage of papers by number of citations

| CITATIONS | N | PERCENTAGE |
|---|---|---|
| No citations | 56 | 34.8 |
| 1–9 citations | 70 | 43.5 |
| 10–19 citations | 24 | 14,9 |
| 20–29 citations | 7 | 4.3 |
| 30–39 citations | 1 | 0.6 |
| 40–49 citations | 1 | 0.6 |
| 50 or more citations | 2 | 1.2 |

Figure 3 shows an author co-citation map, identifying key researchers in the study of technologies in Music Education, including researcher Renée Crawford from Monash University (Melbourne, Australia), with a total of 6 articles (Crawford, 2017; Crawford, 2014; Crawford, 2013; Crawford, 2009; Jenkins & Crawford, 2016; Southcott & Crawford, 2011).

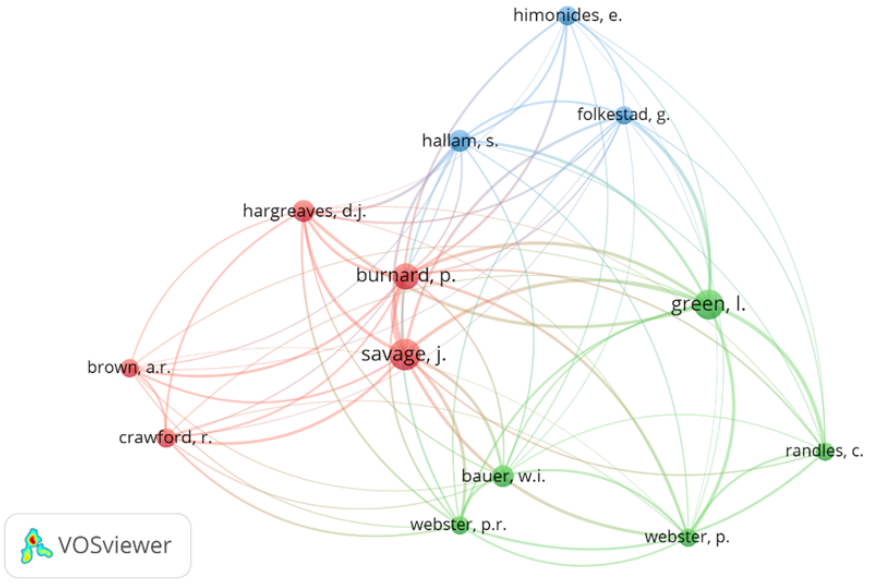


Figure 3. Cross-citation map. Source: VoxViewer

However, the rest of the authors have only one or two articles published on this subject, which results in a Pearson correlation coefficient of r=-0.70, indicating that the variables are moderately dependent and inversely proportional. This is in line with Lotka's law, however the coefficient of determination is $r^2$=0.49, which indicates a medium fit. In addition, Table 7 presents the basic data of the journals with at least 5 papers on this subject, such as their name, number of articles, percentage of the total sample, accumulated citations, and impact index.

Table 7. Journal impact

| JOURNAL | N | % | CITATIONS | IMPACT FACTOR |
|---|---|---|---|---|
| Journal of Music Technology and Education | 22 | 13.7% | 81 | 3.7 |
| International Journal of Music Education | 13 | 8.1% | 105 | 8.1 |
| Music Education Research | 11 | 6.8% | 85 | 7.7 |
| Revista electrónica de LEEME | 9 | 5.6% | 9 | 1 |
| Journal of Music Teacher Education | 8 | 5% | 47 | 5.9 |
| Journal of Research in Music Education | 6 | 3.7% | 81 | 13.5 |

When considering the number of citations received in relation to the years when the papers were published (Figure 4), a significant and strong relationship is found between both variables, calculated using Spearman's correlation coefficient (Table 8). This shows that the impact of the papers published in recent years is higher than in previous years, but the citation trend is slower than in other fields, such as medicine, as can be seen in the spike in citations between 2011 and 2017.

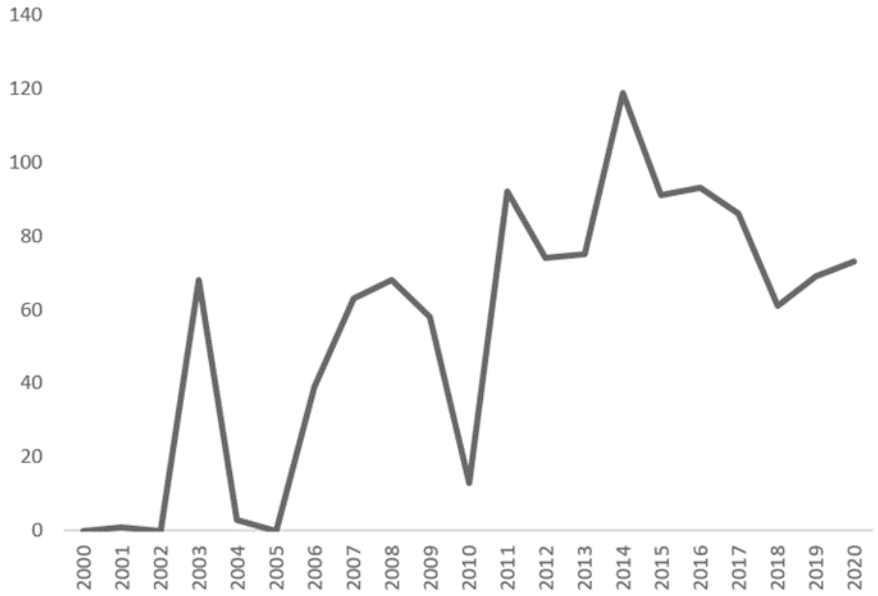


Figure 4. Year/citation correlation. Source: created by the authors.

Table 8. Spearman's correlation coefficient

| INDEX | Variables | Coefficient | YEAR | PUBLICATIONS |
|---|---|---|---|---|
| Spearman's Rho | Year | Correlation coefficient | 1,000 | .725** |
| | | Sig. (bilateral) | . | .000 |
| | | N | 21 | 21 |
| | Publications | Correlation coefficient | .725** | 1,000 |
| | | Sig. (bilateral) | .000 | . |
| | | N | 21 | 21 |

**. The correlation is significant at level 0.01 (bilateral). Source: SPSS.

### 3.1.4 Scattering

When analysing scattering, three zones can be distinguished. Bradford's law shows the relationship between the number of journals and the number of papers published on a topic. As expected, half of the papers were published in a very small number of journals (less than ten, as shown in Figure 5).

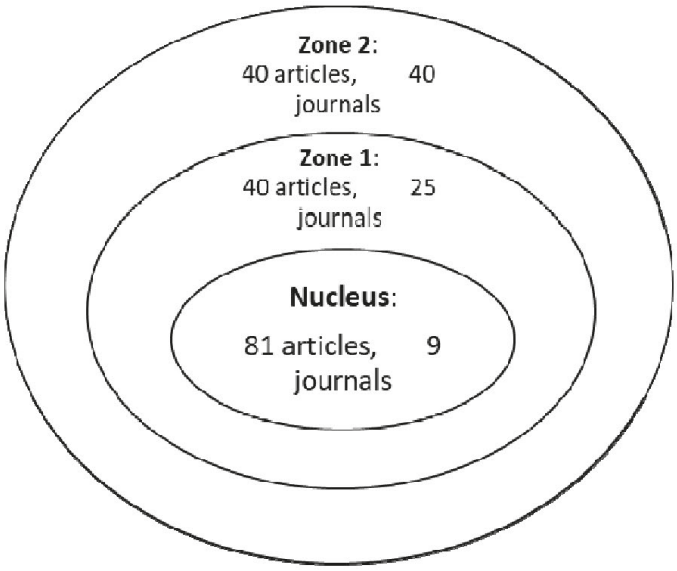


Figure 5. Literature scattering. Source: created by the authors

### 3.2 Content analysis

This content analysis is carried out following two processes. On the one hand, the keywords of the selected studies are explored to identify the nuclei of content around which they are structured. On the other, the content of the studies themselves is analysed using the categories listed in Table 4.

Regarding the keywords, there are some fundamental concepts underlying most of the studies (Figure 6). The two main focuses are precisely music education and technology, understood as a fundamental part of the research process and resulting in the concept that links them together: *music technology*. Information can be found on the main educational stage where research is carried out (higher education), as well as on the participants (teachers in training). Given that this is a stage of formal education, the curriculum is mentioned as the place where the interventions are integrated. The content is present through terms such as *composition* or *popular music*, and one of the major advantages evidenced in the research is also present, namely the development of creativity.

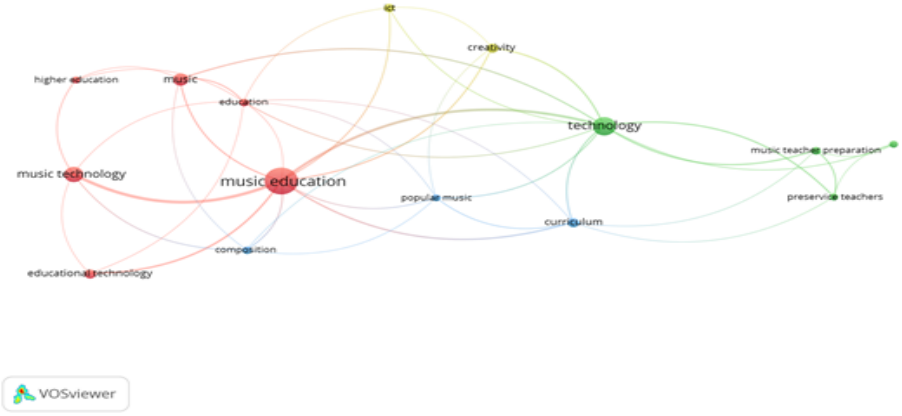


Figure 6. Keyword co-ocurrence map

On the other hand, the approach of the different articles in the sample offers a general overview of the implementation of technology in Music Education. To provide a complete overview, the following categories of analysis have been specifically addressed: educational stage and participants, curricular approach to Music Education, implementation technologies and their use, and results obtained.

Regarding the first variable, it should be noted that most studies focus on Higher Education, especially those that provide research on music teacher training. Specific experiences are found involving the use of specific software (Scratch and MakeyMakey) to improve problem solving (Castro et al., 2020), projects for instrument learning combining technology with the promotion of reflection skills among other things (Arriaga & Riaño, 2017), or studies

based on the TPACK framework developed through methodologies such as problem-based learning (Tejada & Thayer, 2019). This group also includes research carried out in more specific environments such as conservatories, which use technology as a recording tool for reflection (Echevarría & San Martín, 2019) or investigate about the digital competence of teachers and their approaches to technology (Palau et al., 2017). Finally, also contextualised in Higher Education are studies in other Arts and Humanities degrees, which propose the use of virtual learning environments for the development of training processes (Da Silveira, 2016), the use of specific software for musical accompaniment (Li, 2020), or the use of digital materials to teach music (Parasiz, 2018).

However, studies were also conducted in other educational stages. Specific research in primary education stands out, like the studies by Ferreira & Ricoy (2017), Maheirie & Barreto (2019), Ramos & Botella (2016), and Vicente et al. (2018), which analyse the process of creating technological resources and their potential compared to more traditional materials. There are also numerous studies about secondary education, addressing issues such as music learning in virtual environments (Espigares & García, 2011), music teachers' digital competence and attitude towards ICTs (Martos et al., 2016) or the use of specific software for aural training, notation, transcription, and composition (Crawford, 2009). There is even a study that considers both stages (Murillo et al., 2019) and analyses the use of software for music creation and the integration of different artistic languages. Lastly, there is a notable lack of research in early childhood education (Pérez-Moreno & Reverte, 2019). On the other hand, it is worth noting that most of the studies tend to focus on students at these stages, followed by those focusing on teachers, and some authors who approach this issue from a complementary perspective (Crawford, 2013; Romero & Vela, 2014; Supriyatno et al., 2020).

Regarding the curricular approach, most of the research is conducted in the context of specific subjects, such as Music Education (Pećanac et al., 2016) or Art Education (Sáez & Cózar, 2017), with only two studies taking a cross-curricular approach (Rovithis et al., 2019; Rodrigo-Martín et al., 2020). These results allow to conclude that that the integration of music and technology contributes to improving the classroom atmosphere, social values, and acceptance of diversity.

In relation to the technologies used, they are varied. Some models propose a process of hybridisation as the basis for learning (Da Silveira, 2016; Havrilova & Voronova, 2017) and, as noted above others evaluate the impact of specific software for learning music theory (Li, 2020), creating materials (Amaya & Santoyo, 2017), enhancing emotional aspects (García et al., 2013), or in instrument learning (Fernandes et al., 2019; Gorbunova et al., 2020). Most of these cases involve 2.0 software or technologies, seeking to reinforce physical devices through this type of technology. Thus, experiences linked to the hybridisation of training processes, the use of digital learning tools, or the learning of theoretical content emerge as some of the aims of implementating technologies in Music Education training processes.

Finally, the results of the different studies point to the fact that technology has a significant potential in Music Education regarding different aspects, but especially for the development of interdisciplinary competences that go beyond the curricular contents of the discipline. Thus, some contributions, such as Gorbunova et al. (2020) or Havrilova & Voronova (2017), focus on disciplinary aspects such as improving professional competence, learning an instrument, notation, and music theory. However, most studies validate the benefits of technology for active learning, motivation, and self-regulation (Amaya & Santoyo, 2017; Echevarría & San Martín, 2019; Li, 2020), for the social and collaborative construction of learning and knowledge (Arriaga & Riaño, 2017; Maheirie & Barreto, 2019; Murillo et al., 2019), for the improvement of other related skills, such as logical-mathematical thinking or digital skills (Castro et al., 2020; Tejada & Thayer, 2019), or for the overall improvement of academic performance (Pećanac et al., 2016).

## 4. Discussion and conclusions

The combination of bibliometric study and content analysis permitted the identification of key countries, authors, and journals that study the use of technologies in Music Education, as well as the research on designing models with a certain level of reliability. With respect to the latter, it could be observed that incorporating technology from the moment the training action design begins, using it as an alternative to traditional methodologies or resources, and ensuring that the teaching staff are digitally competent are some of the key factors for providing higher quality educational experiences.

Regarding the information extracted from the quantification of the scientific literature, the main laws established for this type of study (Price, Lotka, and Bradford) are met. However, compared to previous studies on other educational topics (Marín et al., 2020; Peirats et al., 2019), the low level of collaboration appears to be a differentiating factor, since in this case most of the papers have only one author, as already noted by Gustems & Calderón (2016).

Regarding content, a diversity of approaches and proposals could be observed. Nonetheless, and although there are studies on the different educational stages, technology is predominantly used for Music Education in higher education contexts. The studies are particularly associated with hybridisation processes (in line with Calderón-Garrido et al., 2019), theoretical learning, or instrument learning through specific software, considering technology from a more instrumental perspective. However, it is important to note that the results show improvements beyond the discipline itself. They provide evidence of technology's potential in teaching Music Education to develop motivation, creativity, as well as social, cognitive and reasoning skills.

Five limitations have been identified. The first of them refers to the use of more databases that include journals other than those available in Scopus and WOS, such as JCR. The second is related to introducing a gender perspective in the analysis. Even though the analysis has allowed for the identification of one very productive female author, gender differences was not the focus. The third is directly related to the use of altmetrics to examine the sample data. In order to explore our object of study in more detail, the fourth is related to being able to carry out an independent in-depth analysis of bibliometrics and content analysis. The last limitation refers to the documents used for content analysis, which were those available in open access, and indicated the importance of sharing knowledge and disseminating research results. Those limitations that depend on the researchers (the first four) have been identified as future lines of research.

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